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Abundance and Distribution of Zooplankton in Hawaiian Waters, 1955-56

By Eugene L. Nakamura

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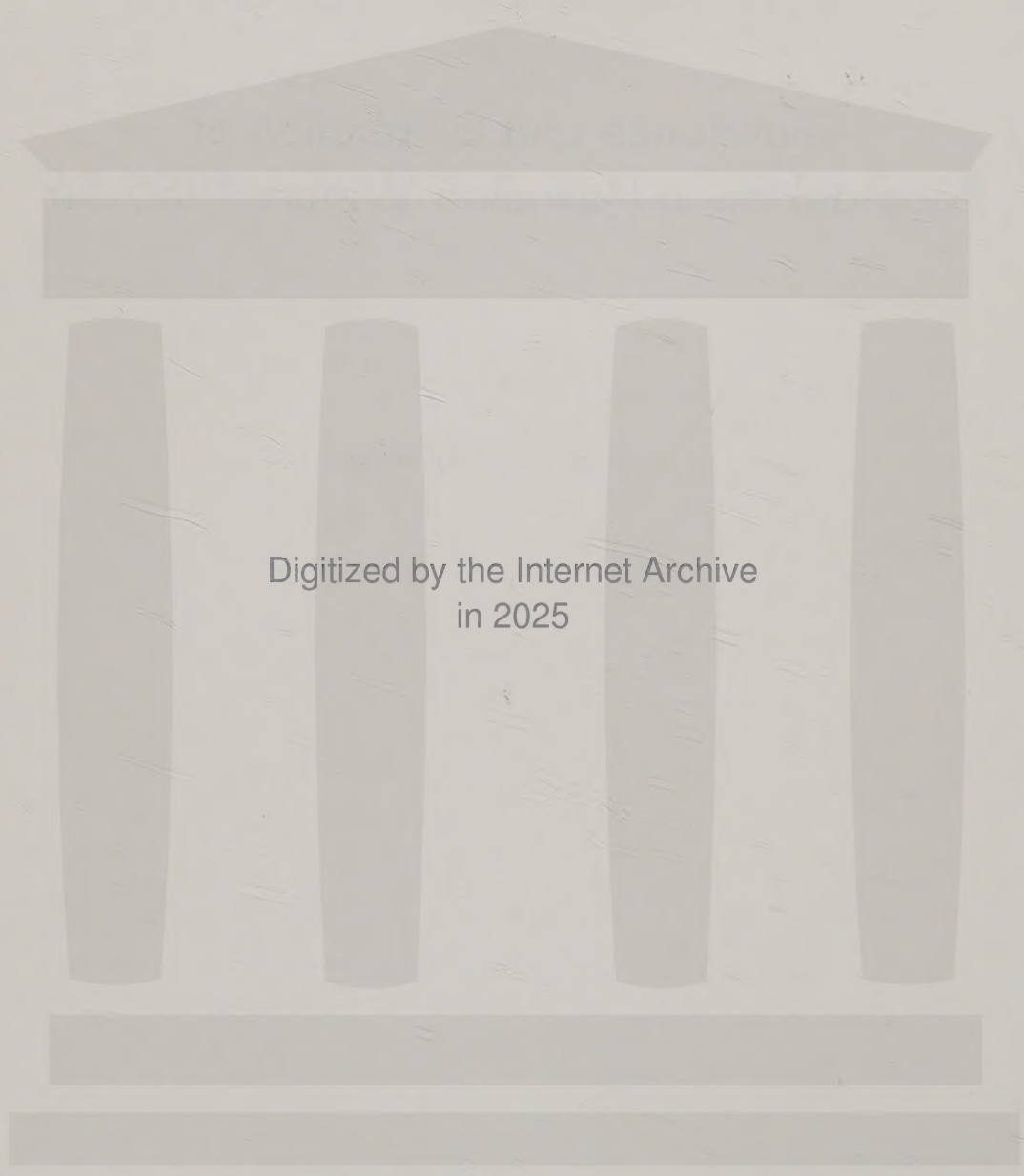

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ABSTRACT

Methods and results of a study of zooplankton are described. Sampling was conducted on eight cruises by vessels of the Bureau of Commercial Fisheries Biological Laboratory, Honolulu, and on nine cruises by the motor vessel Makua of the Hawaii Division of Fish and Game. Sampling included oblique hauls with a single open net at 0 to 60 m. and 0 to 200 m., and three nets towed simultaneously at three levels: an open net at 0 to 60 m. and closing nets at 70 to 130 and at 140 to 200 m. (estimated depths).

The catches from the three-net hauls revealed a greater abundance of zooplankton in the uppermost layer than in deeper water regardless of the time of sampling. Differences existed between windward and leeward areas of the island of Oahu at certain times, but one area did not have consistently greater volumes of zooplankton than the other area throughout the seasons. The significance of seasonal differences was masked by the possibility of annual fluctuations.

Composition of plankton varied by depth, season, and area. Relative abundance was comparatively stable with depth and season. Decapod crustaceans were consistently more abundant in the windward than in the leeward area. Halosphaera viridis, a planktonic alga, was sometimes very numerous. Various groups of zooplankton exhibited conspicuous diel movement.

INTRODUCTION

Results of studies of Hawaiian zooplankton collected in 1950-52 and in 1953-54 have been reported by King and Hida (1954, 1957). This paper presents results from sampling in 1955-56. Spatial and temporal variations in the distribution and abundance of zooplankton are emphasized, but unusual occurrences of phytoplankton are also discussed.

MATERIALS AND METHODS

Table 1 lists the ships, cruises, and dates on which samples of zooplankton were collected. Detailed data for each cruise are presented in tables in the appendix.

Gear

Two types of sampling gear were used in the present study: The three-net series described by King, Austin, and Doty (1957) and the single open net (of the same construction as the upper net in the three-net series) described by King and Demond (1953). The middle and lower nets of the three-net series had opening and closing devices. All nets had a mouth diameter of 1 m. and were equipped with calibrated flowmeters. The hauls lasted about one-half hour. The nets were towed at a ship speed of about 2 knots.

Late in 1956, the silk grit gauze in the main body of the nets (30XXX) and in the rear section and cod end (56XXX) was replaced with nylon. Widths of apertures in the silk and nylon were nearly the same: 0.65 and 0.31 mm. for silk and 0.656 and 0.308 mm. for nylon.[1/]

[1/] E. H. Ahlstrom has informed me that the two nets have different apertures while being towed and also have different straining properties. Unfortunately, records of the type of gauze in the nets, by station and date, are not available.

Table 1.--A list of the ships, cruises, and dates on which samples of zooplankton were collected

Sampling series	Ship	Cruise	Date
Comprehensive	Charles H. Gilbert	24	Nov. 14-18, 1955
Do	Hugh M. Smith	32	Feb. 2-7, 1956
Do	do	34	May 7-11, 1956
Do	do	35	Aug. 1-6, 1956
Do	do	36	Nov. 7-10, 1956
Monitor	John R. Manning	29	Jan. 5-6, 1956
Do	Hugh M. Smith	32	Feb. 3-6, 1956
Do	John R. Manning	30	Mar. 15-16, 1956
Do	do	30	Apr. 19-20, 1956
Do	Hugh M. Smith	34	May 7-11, 1956
Do	do	34	May 29-30, 1956
Do	do	34	June 29-30, 1956
Do	do	35	Aug. 2-5, 1956
Do	John R. Manning	32	Sept. 11-12, 1956
Do	Hugh M. Smith	36	Oct. 18-19, 1956
Do	do	36	Nov. 8-10, 1956
Inshore-offshore	John R. Manning	29	Jan. 5, 1956
Do	Makua	1	Feb. 2-3, 1956
Do	do	2	Mar. 2, 1956
Do	John R. Manning	30	Mar. 15, 1956
Do	Makua	3	Apr. 4, 1956
Do	John R. Manning	30	Apr. 20, 1956
Do	Hugh M. Smith	34	May 7, 1956
Do	do	34	May 29, 1956
Do	Makua	5	June 14, 1956
Do	Hugh M. Smith	34	June 29, 1956
Do	Makua	6	July 11, 1956
Do	Hugh M. Smith	35	Aug. 2-3, 1956
Do	Makua	7	Aug. 22, 1956
Do	John R. Manning	32	Sept. 12, 1956
Do	Makua	8	Oct. 3, 1956
Do	Hugh M. Smith	36	Oct. 19, 1956
Do	do	36	Nov. 10, 1956
Do	Makua	9	Nov. 28, 1956
Do	do	10	Dec. 12, 1956

Sampling Program

The sampling comprised four series:

1. The comprehensive series, to investigate vertical, horizontal, seasonal, and diel fluctuations in abundance of zooplankton. Samples were taken simultaneously at three levels (0-60, 70-130, and 140-200 m.). During one cruise, two kinds of tows were made at alternate stations with a single open net: between the surface and top of the thermocline; and between the surface and 200 m.
2. The monitor series, to determine fluctuations in abundance of zooplankton in windward and leeward areas off Oahu. Oblique hauls were made with an open net between 0 and 60 m.
3. The inshore-offshore series, to evaluate littoral influences on abundance of zooplankton. Oblique hauls were made with an open net between 0 and 60 m.
4. Oblique hauls between 0 and 200 m., to compare abundance of zooplankton with that estimated from similar hauls from previous years.

Treatment of Samples

Volumes of the samples of zooplankton were measured in the laboratory by the displacement method as described by King and Hida (1954, 1957). The samples from the comprehensive series received the following additional treatment:

1. After volumes had been determined for

the organisms smaller than 2 cm., either the entire sample (if the volume was less than 10 cc.) or a fraction of about 10 cc. (from larger samples) was distributed evenly in a counting cell. The cell was a plastic dish 15 by 20 by 1.5 cm., the bottom of which was ruled into 300 squares, each with an area of 1 $cm.^2$.

2. The organisms in 10 randomly selected squares were then identified and counted under a dissecting microscope. Identification was only to major taxonomic groups, as shown in table 11.
3. The estimated number of a particular group of organisms was determined by multiplying the count by 30, if the entire sample had been placed in the plastic dish. If the sample had been fractioned, the count was multiplied by 30 and multiplied again by the reciprocal of the fraction.

Adjustment for Diel Variation

The method of King and Hida (1954) for adjusting volumes of zooplankton for variation with time of collection is based on the similarity between diel variation in the volumes and the curve of the sine function. Midnight was set at 90°, and sine-time values were obtained for the various hours of the day. Then adjusted volumes were computed by regression analysis. After adjustment the night/day ratios were much closer to unity; much of the variation caused by differences in time of sampling clearly had been removed (table 2).

Volumes of samples from the middle and lower nets of the comprehensive series were not adjusted because the regression coefficients did not yield significant values when subjected to a "t" test (Snedecor, 1956). All volumes of samples from the upper nets yielded highly significant values when subjected to the same test. (See table 3 for average depths sampled by the three nets.) All volumes of samples from the monitor series were pooled in making the adjustment, because the numbers of samples from the individual cruises were insufficient for separate treatment. All data for the inshore-offshore series also were combined. Data for the comprehensive series were adjusted separately for each cruise. All later references to "adjusted" and "unadjusted" samples concern this time adjustment.

Table 2.--Comparison of night/day ratios of unadjusted and adjusted volumes of zooplankton

Samples	Night/day ratios	
	Sample volume	Adjusted volume
Comprehensive series		
CHG-24		
Surface to top of thermocline	1.26	0.89
Surface to 200 m.	1.64	1.07
HMS-32 (upper nets)	1.42	1.03
HMS-34 (upper nets)	2.52	0.84
HMS-35 (upper nets)	2.05	1.06
HMS-36 (upper nets)	1.87	1.01
Monitor series	2.18	0.96
Inshore-offshore series	3.11	1.25

Table 3.--Average corrected sampling depths of the nets used in three-net hauls

Net and depth limit	Average corrected sampling depth
	m.
Upper net	
Upper limit	0
Lower limit	49
Middle net	
Upper limit	56
Lower limit	118
Lower net	
Upper limit	126
Lower limit	233

Determinations and Corrections for Depth

The spacing of nets on the towing cable for three-net hauls was based on the assumption that the cable was straight during the haul. This assumption was proved wrong by a depth gage (Miller, Moore, and Kvammen, 1953) used on HMS-31[2/] and a subsequent test cruise. Correction factors were calculated, therefore, from data obtained from the pressure gage.

Approximate sampling depths were first computed by multiplying the cosine of the cable angle by the amount of cable that had been let out. The values obtained were multiplied by the appropriate correction factors to yield the corrected depths.

[2/] Cruises are identified by initials of the ship and the cruise numbers. Examples are: CHG-24 for Charles H. Gilbert cruise 24, JRM-30 for John R. Manning cruise 30, HMS-32 for Hugh M. Smith cruise 32.

Variations from the calculated depths for the single-net hauls were considered to be minor; therefore, corrections were not applied. Depths given in the tables in the appendix for the single-net hauls are to the nearest 5 m.

COMPREHENSIVE SERIES

The comprehensive series was an investigation of vertical, horizontal, and seasonal fluctuations in abundance of zooplankton throughout the waters adjacent to Oahu.

Forty-eight stations were established initially (fig. 1), but their spacing proved to be unsatisfactory during CHG-24, the first cruise. For subsequent cruises, the stations were reduced from 48 to 45 and were spaced more evenly (fig. 2). The stations were visited every 3 months to obtain a measure of seasonal variation. At each station, three nets were towed simultaneously at three levels, an open net at 0 to 60 m., and closing nets at 70 to 130 m. and at 140 to 200 m. to determine vertical differences.

This procedure in which three nets were used was followed exactly on HMS-32, 34, and 35, but not on the other two cruises of the comprehensive series. On CHG-24 (before the closing nets were available), all hauls were made with single open nets; alternate tows were made between the surface and the top of the thermocline (at odd-numbered stations), and between the surface and 200 m. (at even-numbered stations). On HMS-36, owing to the loss of equipment at the first sampling station, only two nets were used: an open net at 0 to 60 m. and a closing net at 70 to 130 m. (here considered the middle net of HMS-36).

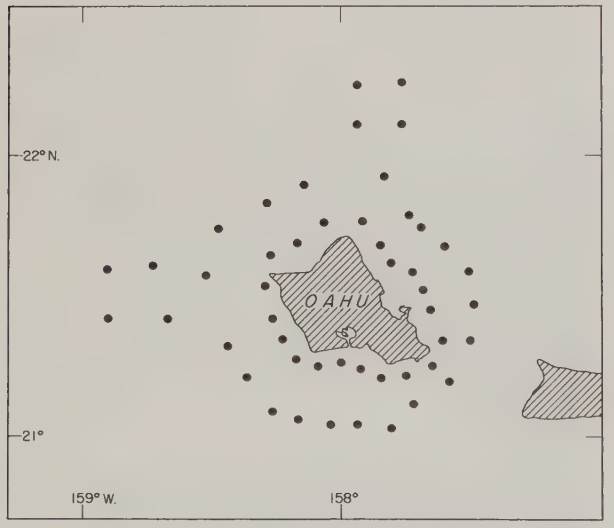

Figure 1.--Stations for collecting zooplankton on CHG-24.

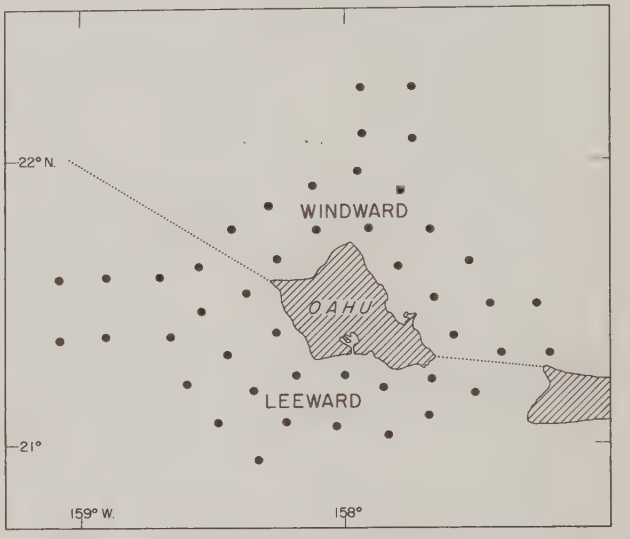

Figure 2.--Stations for collecting zooplankton for comprehensive series. The division between windward and leeward stations is shown by a dotted line.

Vertical Distribution

The catches made on the Hugh M. Smith cruises yielded information on vertical and diel variations in the distribution of zooplankton. Since the volumes of catches in the middle and lower nets of this series did not show a significant regression on the sine curve, they were not adjusted for diel variation. The samples from these three hauls were classified as day, night, or twilight,[3/] according to the time of hauling, and unadjusted volumes were averaged for the samples from each time group (table 4).

The catch of zooplankton decreased with increasing depth regardless of the time of day. The single discrepancy was for HMS-34, when the average catch in the middle net was greater than that in the upper net during the day but about equal to it at night.

The quantities of zooplankton in the different strata of water during different light periods were compared on the basis of pooled data from the four cruises (table 5). In night hauls the middle stratum yielded an average of about 2.9 times, and the upper stratum about 4.4 times,

[3/] The hours of each time interval were determined from the American Nautical Almanac.

Table 4.--Average volumes of zooplankton from three-net hauls on HMS-32, 34, and 35, and from two-net hauls on HMS-36

Net and light period	HMS-32		HMS-34		HMS-35		HMS-36	
	Average volume	Samples	Average volume	Samples	Average volume	Samples	Average volume	Samples
	cc./1,000 m.^{3}	Number	cc./1,000 m.^{3}	Number	cc./1,000 m.^{3}	Number	cc./1,000 m.^{3}	Number
Upper net	23.3	43	16.9	45	21.8	45	16.8	44
Day	19.9	22	10.7	27	14.8	25	12.1	19
Twilight	21.0	4	24.3	5	31.4	5	14.5	7
Night	28.3	17	27.0	13	30.3	15	22.7	18
Middle net	15.8	37	19.5	28	16.1	44	9.1	29
Day	15.6	16	17.3	17	14.4	24	6.6	15
Twilight	14.8	4	14.5	4	16.7	5	8.9	3
Night	16.4	17	27.5	7	18.7	15	12.5	11
Lower net	5.0	23	4.9	31	6.2	33	---	---
Day	4.0	13	4.2	18	6.4	20	---	---
Twilight	4.7	1	5.1	4	6.7	2	---	---
Night	6.3	9	6.4	9	5.9	11	---	---

Table 5.--Average ratios of volume of zooplankton in various strata of water sampled by three nets on HMS-32, 34, and 35, and by two nets on HMS-36

Light period	Average ratio		
	Upper/middle	Upper/lower	Middle/lower
Day	1.04	2.86	2.74
Twilight	1.56	4.01	2.58
Night	1.52	4.36	2.88

Table 6.--Average volumes of zooplankton in two strata of water during different periods of the day on CHG-24

Stratum sampled and light period	Average volume	Samples
Surface to top of thermocline	cc./1,000 m.^{3}	Number
All periods	20.0	24
Day	17.7	9
Twilight	18.6	3
Night	22.2	12
Surface to 200 m.		
All periods	12.7	24
Day	9.9	10
Twilight	10.6	4
Night	16.3	10

the quantity of zooplankton from the lower stratum. During the day, average volumes in the upper stratum were only slightly larger than in the middle stratum. The ratio increased from near unity during the day to about 1.5 at night, probably as a result of the movement of zooplankton toward the surface at night.

The evidence of a greater concentration of zooplankton in the upper layers, both at night and during the day, is in agreement with the findings of King and Hida (1957) and others. From open-net, oblique hauls to a depth of 100 m., King and Hida (1957) obtained average volumes 1.6 times the average volumes from hauls to a depth of 200 m. Coincidentally, the same ratio, 1.6, was obtained during CHG-24, when the average unadjusted volume from the shallow, open-net, oblique hauls between the surface and the top of the thermocline (average depth 78 m.) was divided by the average unadjusted volume from the hauls at the alternate stations between the surface and 200 m. (table 6). Volumes of zooplankton again were greater in the upper stratum, regardless of the time of sampling.

Horizontal Distribution

The region sampled in the comprehensive series was subdivided into leeward and windward areas (fig. 2), for comparisons of abundance of zooplankton for each cruise (table 7). (In the Hawaiian Islands, the prevailing winds are from the northeast most of the year.) Differences between the two areas were significant only in the upper net, and only during November 1955 (CHG-24) and May 1956 (HMS-34).

Although their areal coverage of Hawaiian waters was much greater than that reported here, King and Hida (1954, 1957) found no differences in abundance of zooplankton between windward and leeward areas.

Variations in density of zooplankton around Oahu are illustrated in figures 3, 4, 5, 6, and 7 for CHG-24 and the Smith cruises. An average and a standard deviation were computed from the adjusted volumes for the series of shallow-

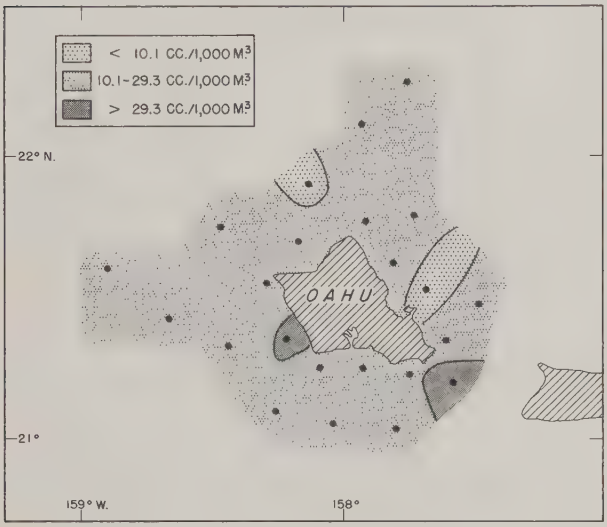

Figure 3.--Density of zooplankton around Oahu, November 14-18, 1955 (CHG-24, odd-numbered stations).

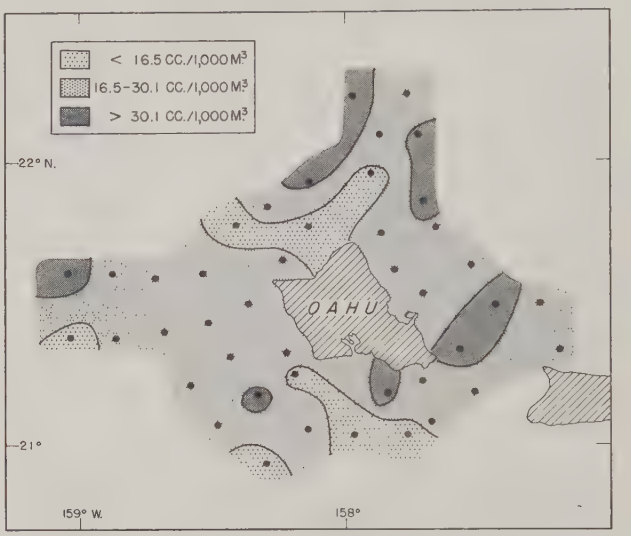

Figure 4.--Density of zooplankton around Oahu, February 2-7, 1956 (HMS-32, upper net).

Table 7.--Comparison of average volumes of zooplankton (cc. per 1,000 m.^{3}) between windward and leeward areas off Oahu for the upper, middle, and lower nets of the Smith cruises, 1956[1/] [n = number of samples; $\bar{x}$ = average volume; s = standard deviation; t = statistic for testing hypothesis; P = probability]

Cruise	Date	Windward			Leeward			t	P
		n	$\bar{x}$	s	n	$\bar{x}$	s		
				Upper net[2/]					
CHG-24	Nov. 1955	12	15.7	5.7	12	23.6	11.3	2.16	<0.05
HMS-32	Feb. 1956	20	24.7	6.6	23	22.1	6.8	1.27	>0.05
HMS-34	May 1956	21	18.2	7.8	24	12.5	10.0	2.10	<0.05
HMS-35	Aug. 1956	21	22.3	9.5	24	18.5	6.6	0.61	>0.05
HMS-36	Nov. 1956	21	15.4	4.8	23	16.4	5.0	0.67	>0.05
				Middle net[2/]					
HMS-32	Feb. 1956	18	15.6	10.6	19	16.1	5.6	0.18	>0.05
HMS-34	May 1956	13	16.1	8.6	15	22.4	12.4	1.54	>0.05
HMS-35	Aug. 1956	20	17.1	7.3	24	15.4	7.7	0.74	>0.05
HMS-36	Nov. 1956	13	9.6	5.4	16	8.6	3.7	0.10	>0.05
				Lower net[2/]					
HMS-32	Feb. 1956	10	4.8	3.0	13	5.1	3.0	0.23	>0.05
HMS-34	May 1956	15	4.5	3.0	16	5.3	2.2	0.73	>0.05
HMS-35	Aug. 1956	17	6.8	3.4	16	5.7	3.8	0.85	>0.05

[1/] One series of tows between the surface and the top of the thermocline, during CHG-24 in November 1955, is included with the upper-net tows.

[2/] Volumes from upper net were adjusted for diel variation. Volumes from middle and lower nets were not.

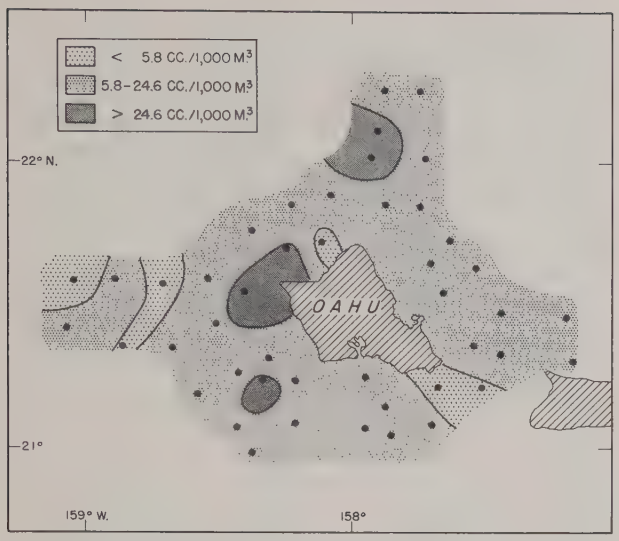

Figure 5.--Density of zooplankton around Oahu, May 7-11, 1956 (HMS-34, upper net).

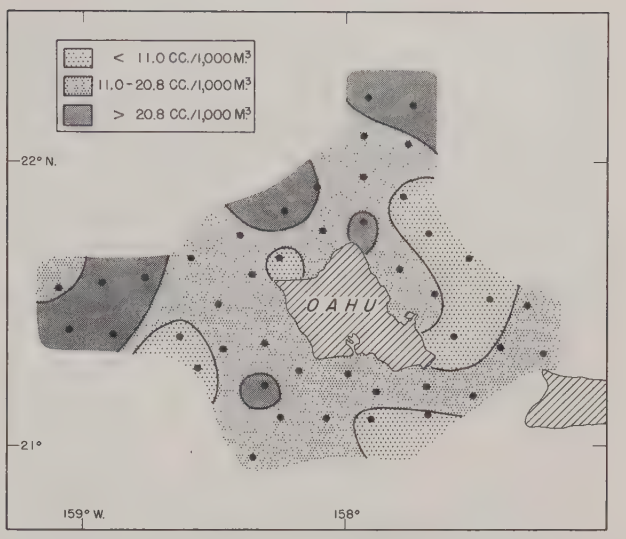

Figure 7.--Density of zooplankton around Oahu, November 7-10, 1956 (HMS-36, upper net).

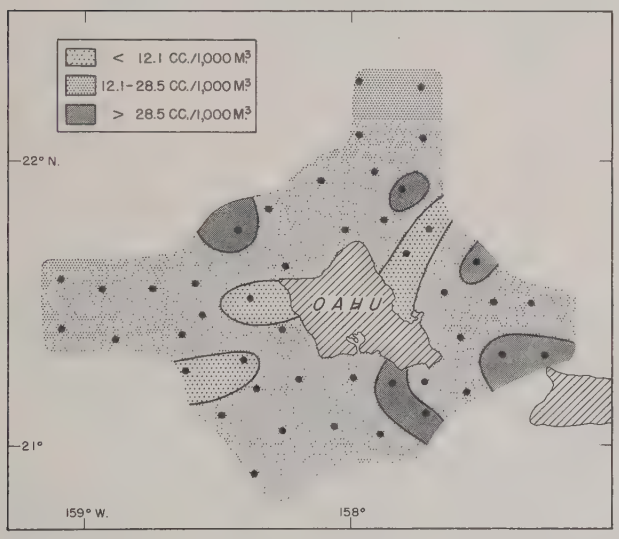

Figure 6.--Density of zooplankton around Oahu, August 1-6, 1956 (HMS-35, upper net).

est hauls of each cruise. Areas with densities greater than the average plus one standard deviation were designated as "rich" and those with densities less than the average minus one standard deviation as "poor." No particular area was consistently "rich" or "poor."

Seasonal Distribution

The Smith cruises were scheduled at 3-month intervals. Seasonal variations in abundance of zooplankton were indicated by the variation in catches in the upper net during the different cruises (table 7).

The average volumes of zooplankton for the upper stratum, both unadjusted (table 4) and adjusted (table 8), show that abundance of zooplankton was greater in the winter (HMS-32) and summer (HMS-35) than in the spring (HMS-34) and fall (HMS-36). In contrast, King and

Table 8.--Analysis of variance of adjusted volumes of zooplankton (cc. per 1,000 $m.^3$) in different seasons for the upper net of the Smith cruises [n = number of samples; $\bar{x}$ = average volume; s = standard deviation; F = statistic for testing hypothesis; P = probability]

Cruise and month (1956)				
Item	HMS-32 Feb.	HMS-34 May	HMS-35 Aug.	HMS-36 Nov.
n	43	45	45	44
$\bar{x}$	23.3	15.2	20.3	15.9
s	6.8	9.4	8.2	4.9

Treatment of data					
Source of variation	Degrees of freedom	Sum of squares	Mean square	F	P
Total	176	11,715.60			
Season means	3	1,923.66	641.22	11.3	<0.01
Individuals	173	9,791.94	56.60		

Hida (1954) found a greater abundance during May (unadjusted average = 15.9 cc./1,000 m.^{3}) than in August (unadjusted average = 12.6) for 1950. For 1951 they found a significant difference between July (adjusted average = 25.6 and October-November (adjusted average = 20.3).

The seasonal variations in the middle stratum (table 4) do not follow those of the upper layer. Discrepant results such as these make uncertain the significance of data on seasonal fluctuations, particularly since annual variations may mask seasonal variations.

Variations in Composition

Plankton counts were made on all samples in the comprehensive series to detect gross changes in composition. Identification was only to general categories (table 9); further identification was considered impractical. A few categories represented in the collections are not listed in the tables because they composed such small percentages of the total count. Colonial forms and fragile organisms such as radiolarians, siphonophores, and polychaetous annelids

Table 9.--Percentage composition and average number of organisms per 1,000 m.^{3} of water strained by the upper net on the Smith cruises and by the net towed between the surface and the top of the thermocline on CHG-24

Item	Cruise				
	CHG-24	HMS-32	HMS-34	HMS-35	HMS-36
Cruise period	Nov. 1955	Feb. 1956	May 1956	Aug. 1956	Nov. 1956
Number of samples	24	43	45	44	44
Number of day hauls	9	22	27	25	19
Number of night hauls	12	17	13	14	18
Number of twilight hauls	3	4	5	5	7
Avg. sample vol. (cc./1,000 m.^{3})	20.0	23.3	16.9	21.8	16.8
Avg. adjusted vol. (cc./1,000 m.^{3})	19.7	23.3	15.2	20.3	15.9

Organism	Number per 1,000 m.^{3}	Percentage	Number per 1,000 m.^{3}	Percentage	Number per 1,000 m.^{3}	Percentage	Number per 1,000 m.^{3}	Percentage	Number per 1,000 m.^{3}	Percentage
Foraminifera	383	1.3	194	0.6	101	0.5	1,222	4.5	247	1.0
Radiolaria	492	2.1	653	2.3	428	2.1	1,445	4.0	166	0.7
Siphonophora	2,167	9.1	1,505	4.8	1,228	5.7	3,413	11.9	2,483	10.0
Medusae	4	<0.1	45	0.1	54	0.2	4	<0.1	34	0.2
Chaetognatha	1,448	5.4	1,375	4.4	1,241	5.0	2,303	7.4	1,675	6.6
Polychaeta	106	0.4	229	0.6	198	0.7	131	0.4	94	0.4
Copepoda	11,538	42.5	14,526	42.8	12,826	49.9	13,486	40.9	12,525	49.6
Ostracoda	2,000	7.1	1,694	4.4	3,864	9.9	2,079	5.3	1,114	3.6
Euphausiacea	936	3.6	951	2.5	1,312	3.6	2,206	6.5	1,622	5.6
Amphipoda	549	1.7	557	1.5	456	1.6	431	1.4	474	1.7
Stomatopoda	11	<0.1	10	<0.1	8	<0.1	44	0.1	56	0.2
Mysidacea	8	<0.1	16	<0.1	5	<0.1	8	<0.1	4	<0.1
Decapoda (Crustacea)	1,142	4.4	1,191	3.4	1,171	4.3	1,670	5.1	1,247	4.5
Pteropoda	445	1.7	478	1.2	518	1.7	672	1.9	291	1.1
Heteropoda	166	0.7	36	0.1	77	0.4	154	0.5	75	0.3
Gastropoda (Larvae)	185	0.7	214	0.7	97	0.5	53	0.2	118	0.5
Pelecypoda	51	0.2	116	0.4	37	0.2	20	0.1	51	0.2
Thaliacea	205	0.8	2,349	8.0	435	2.0	647	2.1	606	2.4
Appendicularia	592	1.9	800	2.2	292	1.3	387	1.3	528	2.2
Fish (Larvae)	140	0.6	265	0.8	242	0.9	369	1.1	188	0.7
Fish (Eggs)	124	0.5	132	0.5	385	1.7	273	0.8	60	0.3
Halosphaera	3,414	12.1	4,958	16.0	1,128	6.5	781	3.0	1,664	7.1

are easily fragmented during sampling and handling in the laboratory. Each fragment was counted as an individual (following Welch, 1948: p. 287).

Although most phytoplankton passed through the mesh of the net, one alga, Halosphaera viridis Schmitz, was so common that it is included in all the counts.

The averages of the number of organisms per 1,000 $m.^3$ of water and the averages of the percentage composition of the plankton are tabulated for the CHG-24 and Smith cruises in tables 9, 10, and 11. By number, copepods make up about half of the catch. King and Demond (1953) and Hida and King (1955) also found that copepods were the most numerous zooplankters in central Pacific areas.

Numerically as well as in percentage of total volume of the catch, the upper net in the three-net series nearly always produced the most zooplankton and the lower net the least. This situation is clearly demonstrated if the data are rearranged by rank (table 12). Ostracods were the only organisms that were consistently more abundant in the middle stratum. Siphonophores, decapod crustaceans, pteropods, gastropod larvae, pelecypods, appendicularians, and fish eggs were uniformly most plentiful in the upper stratum and least abundant in the lower stratum.

Decapod crustaceans were consistently more abundant in the windward than in the leeward area in samples from the upper net (table 13). Several other taxa--the euphasiids, amphipods, and appendicularians--were also more abundant in the windward area, but the difference in numbers between the two areas was not as great. In the middle net, amphipods were uniformly more abundant on the windward side and heteropods were more abundant on the leeward side (table 14). In the lower net foraminifers and

Table 10.--Percentage composition and average number of organisms per 1,000 $m.^3$ of water strained by the middle net on the Smith cruises

Item	Cruise			
	HMS-32	HMS-34	HMS-35	HMS-36
Cruise period (1956)	Feb.	May	Aug.	Nov.
Number of samples	37	28	44	29
Number of day hauls	16	17	24	15
Number of night hauls	17	7	15	11
Number of twilight hauls	4	4	5	3
Avg. sample vol. (cc./1,000 $m.^3$)	15.8	19.5	16.1	9.1

Organism	Number per 1,000 $m.^3$	Percentage	Number per 1,000 $m.^3$	Percentage	Number per 1,000 $m.^3$	Percentage	Number per 1,000 $m.^3$	Percentage
Foraminifera	249	1.4	69	0.3	624	3.3	190	1.4
Radiolaria	327	2.0	427	1.4	344	1.7	179	1.4
Siphonophora	576	2.8	1,022	3.3	1,331	6.6	424	4.6
Chaetognatha	1,274	6.5	2,192	7.2	1,605	7.5	1,041	9.3
Polychaeta	273	1.2	110	0.4	111	0.6	93	0.8
Copepoda	11,129	48.2	16,188	52.0	11,907	49.8	6,607	50.9
Ostracoda	2,690	13.2	4,876	15.9	2,606	11.6	1,214	9.3
Euphausiacea	870	3.7	1,488	4.6	1,357	6.1	895	6.7
Amphipoda	612	3.4	850	3.0	529	2.4	291	2.7
Decapoda (Crustacea)	587	2.8	482	1.6	459	2.0	272	2.3
Pteropoda	231	1.1	403	1.5	307	1.5	114	0.9
Heteropoda	48	0.2	54	0.2	64	0.3	27	0.2
Gastropoda (Larvae)	125	0.7	27	0.1	41	0.2	13	0.1
Pelecypoda	33	0.1	23	0.1	16	0.1	11	0.2
Thaliacea	1,171	4.1	807	2.6	425	2.2	244	2.0
Appendicularia	202	0.8	212	0.6	48	0.2	85	0.7
Fish (Larvae)	161	0.8	250	0.9	167	0.7	75	0.6
Fish (Eggs)	26	0.1	66	0.2	59	0.3	10	0.1
Halosphaera	1,073	4.6	764	3.2	755	3.9	442	4.0

Table 11.--Percentage composition and average number of organisms per 1,000 m.^{3} of water strained by the lower net on the Smith cruises

Item	Cruise					
	HMS-32		HMS-34		HMS-35	
Cruise period (1956)	Feb.		May		Aug.	
Number of samples	23		31		33	
Number of day hauls	13		18		20	
Number of night hauls	9		9		11	
Number of twilight hauls	1		4		2	
Avg. sample vol. (cc./1,000 m.^{3})	5.0		4.9		6.2	
Organism	Number per 1,000 m.^{3}	Per-cent-age	Number per 1,000 m.^{3}	Per-cent-age	Number per 1,000 m.^{3}	Per-cent-age
Foraminifera	208	3.1	28	0.3	137	1.7
Radiolaria	184	2.7	59	0.7	78	0.8
Siphonophora	266	4.0	206	2.7	276	2.7
Chaetognatha	287	4.2	603	7.4	708	7.3
Polychaeta	52	0.5	34	0.4	68	0.6
Copepoda	3,927	54.6	4,399	51.4	4,288	43.5
Ostracoda	1,033	16.6	2,217	20.4	1,296	12.9
Euphausiacea	207	2.7	450	5.0	548	4.8
Amphipoda	177	2.8	340	3.8	239	2.6
Decapoda (Crustacea)	58	0.9	116	1.2	40	0.6
Pteropoda	121	2.1	277	2.7	157	1.5
Heteropoda	8	0.1	7	<0.1	7	0.1
Gastropoda (Larvae)	10	0.3	14	0.1	6	0.1
Pelecypoda	4	0.1	16	0.2	11	0.1
Thaliacea	43	0.7	62	0.7	76	0.8
Appendicularia	5	0.1	16	0.1	11	0.1
Fish (Larvae)	7	0.1	37	0.4	15	0.2
Fish (Eggs)	26	0.4	14	0.2	17	0.2
Halosphaera	203	2.6	150	1.6	1,502	12.9

Table 12.--Ranks for average numbers of organisms per 1,000 m.^{3} of water strained by the different nets on the Smith cruises. (The layer--upper, middle, lower--in which organism was most numerous is indicated by rank 1, and least numerous by rank 3.)

Organism	HMS-32			HMS-34			HMS-35			HMS-36	
	Upper	Middle	Lower	Upper	Middle	Lower	Upper	Middle	Lower	Upper	Middle
Foraminifera	3	1	2	1	2	3	1	2	3	1	2
Radiolaria	1	2	3	2	1	3	1	2	3	2	1
Siphonophora	1	2	3	1	2	3	1	2	3	1	2
Chaetognatha	1	2	3	2	1	3	1	2	3	1	2
Polychaeta	2	1	3	1	2	3	1	2	3	2	1
Copepoda	1	2	3	2	1	3	1	2	3	1	2
Ostracoda	2	1	3	2	1	3	2	1	3	2	1
Euphausiacea	1	2	3	2	1	3	1	2	3	1	2
Amphipoda	2	1	3	2	1	3	2	1	3	1	2
Decapoda (Crustacea)	1	2	3	1	2	3	1	2	3	1	2
Pteropoda	1	2	3	1	2	3	1	2	3	1	2
Heteropoda	2	1	3	1	2	3	1	2	3	1	2
Gastropoda (Larvae)	1	2	3	1	2	3	1	2	3	1	2
Pelecypoda	1	2	3	1	2	3	1	2	3	1	2
Thaliacea	1	2	3	2	1	3	1	2	3	1	2
Appendicularia	1	2	3	1	2	3	1	2	3	1	2
Fish (Larvae)	1	2	3	2	1	3	1	2	3	1	2
Fish (Eggs)	1	2.5	2.5	1	2	3	1	2	3	1	2
Halosphaera	1	2	3	1	2	3	2	3	1	1	2

Table 13.--Comparison of average number of organisms per 1,000 $m.^3$ of water strained by the upper net in windward and leeward areas (number of samples shown in parentheses)

Organism	HMS-32		HMS-34		HMS-35		HMS-36	
	Windward	Leeward	Windward	Leeward	Windward	Leeward	Windward	Leeward
	(20)	(23)	(21)	(24)	(21)	(24)	(21)	(23)
Foraminifera	209	181	130	75	644	1,677	312	189
Radiolaria	620	682	516	351	1,322	1,492	190	145
Siphonophora	1,554	1,462	1,565	934	3,168	3,485	2,270	2,678
Chaetognatha	1,290	1,450	1,546	974	2,834	1,738	1,828	1,536
Polychaeta	197	257	217	181	106	147	97	91
Copepoda	16,953	12,415	14,479	11,380	12,993	13,356	13,040	12,054
Ostracoda	1,791	1,610	3,579	4,114	2,386	1,724	1,550	716
Euphausiacea	977	928	1,548	1,106	2,500	1,858	2,090	1,196
Amphipoda	688	444	605	325	441	403	593	366
Decapoda (Crustacea)	1,840	627	1,564	826	2,474	897	1,794	748
Pteropoda	540	424	420	604	736	587	344	243
Heteropoda	2	66	94	63	160	143	55	93
Gastropoda (Larvae)	204	223	104	91	44	59	135	102
Pelecypoda	72	154	58	19	15	22	46	56
Thaliacea	2,132	2,538	546	338	584	675	481	720
Appendicularia	1,046	587	390	207	474	294	555	502
Fish (Larvae)	255	273	287	203	365	357	209	164
Fish (Eggs)	77	179	565	227	280	256	92	30
Halosphaera	2,710	6,912	1,033	1,212	1,031	529	1,703	1,628
Total	33,157	31,412	29,246	23,230	32,557	29,699	27,384	23,257

Table 14.--Comparison of average number of organisms per 1,000 $m.^3$ of water strained by the middle net in windward and leeward areas (number of samples shown in parentheses)

Organism	HMS-32		HMS-34		HMS-35		HMS-36	
	Windward	Leeward	Windward	Leeward	Windward	Leeward	Windward	Leeward
	(18)	(19)	(13)	(15)	(20)	(24)	(13)	(16)
Foraminifera	119	372	27	105	385	824	237	152
Radiolaria	231	417	361	485	386	308	96	247
Siphonophora	601	552	1,031	1,014	1,595	1,112	356	479
Chaetognatha	1,383	1,171	2,220	2,167	1,770	1,466	960	1,107
Polychaeta	247	297	139	84	120	199	60	120
Copepoda	6,052	10,676	14,575	17,586	15,420	8,979	7,671	5,743
Ostracoda	2,663	2,716	4,889	4,864	2,732	2,502	1,341	1,111
Euphausiacea	724	1,010	1,297	1,653	1,117	1,557	903	888
Amphipoda	626	599	880	824	628	446	354	240
Decapoda (Crustacea)	748	433	433	524	408	500	389	176
Pteropoda	718	296	338	459	353	269	56	161
Heteropoda	24	72	37	69	61	66	21	33
Gastropoda (Larvae)	128	121	34	20	46	38	7	18
Pelecypoda	31	35	22	23	32	2	21	4
Thaliacea	1,661	706	813	801	353	484	191	288
Appendicularia	315	94	234	192	49	47	49	114
Fish (Larvae)	147	175	222	274	182	155	68	81
Fish (Eggs)	23	30	52	77	44	73	4	15
Halosphaera	757	1,371	767	761	745	764	321	541
Total	17,198	21,143	28,371	31,982	26,426	19,791	13,105	11,518

pteropods were consistently more abundant on the leeward side, and the siphonophores and thaliaceans on the windward side (table 15).

The season of maximum abundance differed widely among taxa and varied also according to water stratum (tables 9 and 10). In the upper layer the seasons of peak abundance for various taxa were: spring--ostracods and fish eggs; summer--foraminifers, radiolarians, siphonophores, chaetognaths, euphausiids, decapod crustaceans, pteropods, and fish larvae; and winter--polychaetes, copepods, amphipods, gastropod larvae, pelecypods, thaliaceans, appendicularians, and Halosphaera. In the middle layer the seasons of peak abundance were: spring--chaetognaths, euphausiids, pteropods, and fish eggs; summer--foraminifers and siphonophores; and winter--polychaetes, gastropod larvae, pelecypods, thaliaceans, and Halosphaera. In neither the upper nor the middle layer was any taxon (except for the poorly represented stomatopods) most numerous in the fall.

The greater abundance of some taxa in summer may have been associated with abundant food in the form of a bloom of diatoms (discussed in a later section). Both the diatom and zooplankton peaks were in the upper layer.

A substantial increase in Halosphaera occurred in the lower stratum during the summer (HMS-35), apparently as the result of a seasonal shift in population from the upper two strata (table 11). Whether this shift was related to light conditions in the summer or to other factors is not known. Unfortunately, no samples were taken from the lower stratum during the fall (HMS-36).

Total abundance of organisms in the upper stratum was greater on the windward than the leeward side on all four cruises (table 13). This areal difference is attributable to the predominance of decapod crustaceans on the windward side, as mentioned above. Differences between areas were slight in the middle and lower strata (tables 14 and 15).

Collections during November cruises CHG-24 in 1955 and HMS-36 in 1956 provide extremely limited data for a comparison of annual differences in plankton composition. Numbers of most groups of plankters were similar during the 2 years (table 9). Notable exceptions were the radiolarians, ostracods, euphausiids, thaliaceans, fish eggs, and Halosphaera, whose numbers differed greatly in the 2 years.

Table 15.--Comparison of average number of organisms per 1,000 $m.^3$ of water strained by the lower net in windward and leeward areas (number of samples shown in parentheses)

Organism	HMS-32		HMS-34		HMS-35	
	Windward	Leeward	Windward	Leeward	Windward	Leeward
	(10)	(13)	(15)	(16)	(17)	(16)
Foraminifera	167	239	7	47	92	181
Radiolaria	172	193	55	62	104	55
Siphonophora	273	261	281	135	330	234
Chaetognatha	295	282	426	769	993	450
Polychaeta	62	44	24	44	85	54
Copepoda	4,033	3,846	3,868	4,896	5,306	3,791
Ostracoda	1,092	987	1,468	2,919	1,357	1,313
Euphausiacea	167	238	486	416	342	801
Amphipoda	171	182	277	399	289	201
Decapoda (Crustacea)	97	28	54	173	29	54
Pteropoda	88	146	220	331	138	186
Heteropoda	19	0	3	10	9	6
Gastropoda (Larvae)	12	8	9	18	6	7
Pelecypoda	3	6	2	28	20	2
Thaliacea	61	30	72	53	99	57
Appendicularia	12	0	20	11	11	12
Fish (Larvae)	9	5	37	38	21	9
Fish (Eggs)	40	15	13	15	20	14
Halosphaera	88	291	140	159	1,813	1,265
Total	6,861	6,801	7,462	10,523	11,064	8,692

Diel Variation

Diel variation in catch was marked for the following groups during HMS-32 and 34: polychaetes, ostracods, euphausiids, amphipods, pteropods, and fish larvae (figs. 8 and 9).

The major peaks of abundance were during darkness. Certain organisms, e.g., polychaetes, ostracods, amphipods, pteropods, and fish larvae, displayed two major peaks, one before and one after midnight. These peaks probably represent movements of the organisms toward the surface during twilight and temporary withdrawal near midnight. Most of the densities were lowest at about noon. Although the greater portion of these variations may be attributable to vertical migrations by zooplankters, variations due to increased dodging of the net during daylight cannot be discounted. If dodging were the main factor, however, one would expect plateaus in the volume of catch during the day and night and a sharp change during twilight, instead of the definite peaks and depressions that apparently are not directly related to the amount of available light. The many factors influencing diel migrations of zooplankters were reviewed by Kikuchi (1930) and Cushing (1951).

Diel movement was not clearly shown by the copepods as a whole, but the calanoid groups, considered separately, showed such movement (fig. 10).

During the processing of the samples from HMS-34, the prevalent genera of calanoid copepods were counted. The genera that showed the greatest diel variation were Pleuromamma, Neocalanus, Candacia, Undinula, and Euchaeta (figs. 11 and 12). Peaks during twilight and a decline near midnight were evident. Haloptilus preferred deeper waters regardless of the time (fig. 12).

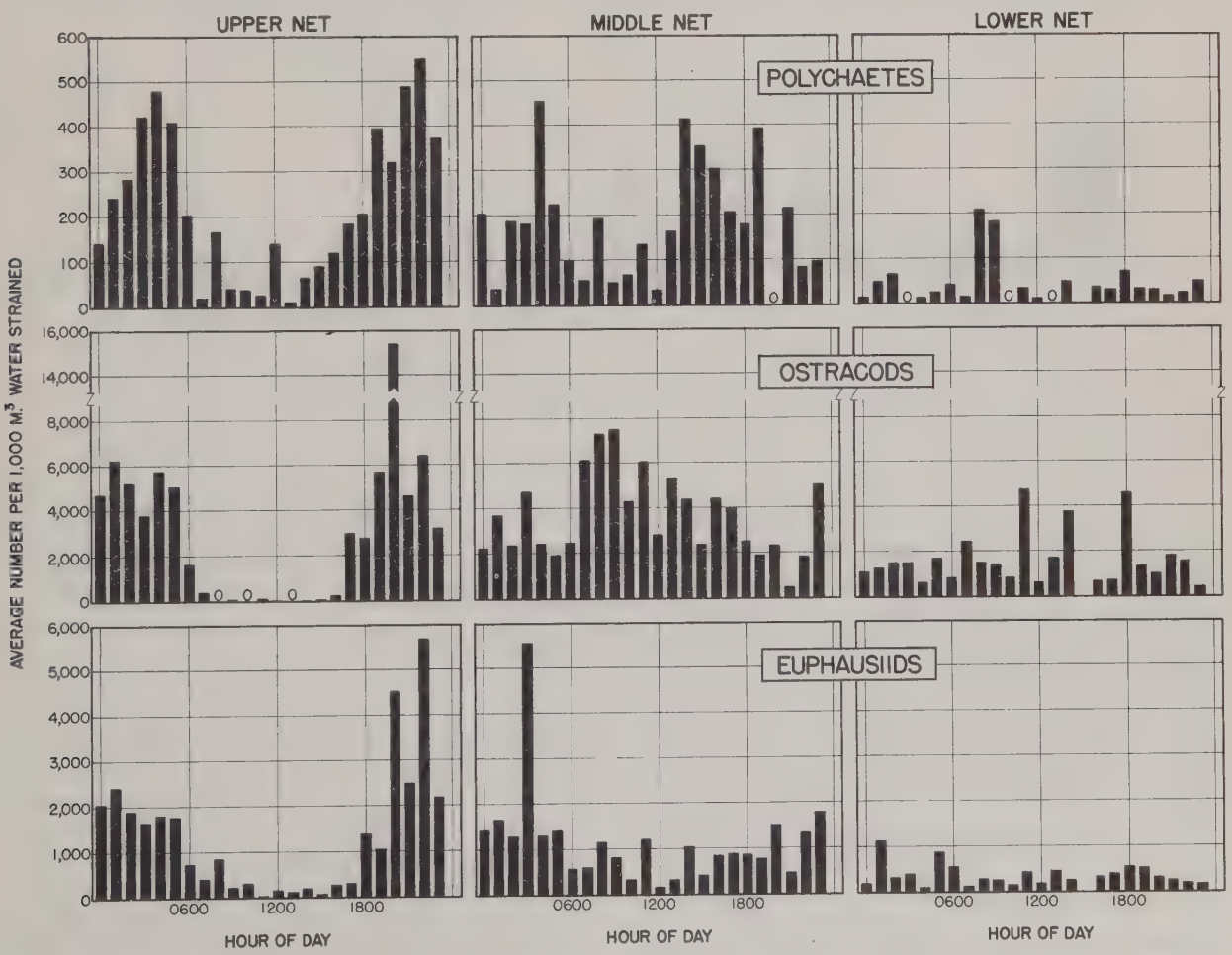

Figure 8.--Average number of polychaetes, ostracods, and euphausiids per 1,000 m.^{3} of water strained by the three nets on HMS-32 and 34.

Figure 9.--Average number of amphipods, pteropods, and fish larvae per 1,000 m.^{3} of water strained by the three nets on HMS-32 and 34.

Phytoplankton Bloom

An occurrence of unusually dense phytoplankton was encountered on August 1-6, 1956 (HMS-35). It was so abundant at certain stations that it clogged the coarse-meshed nets. Thorough washing was required after each tow, before the nets could be re-used.

The principal phytoplankter in the samples was a diatom, Rhizosolenia sp. As a rough measure of abundance, its percentage contribution to the sample volume was estimated (fig. 13).

MONITOR SERIES

The monitor series provided information on monthly fluctuations and on differences in abundance of zooplankton between windward and leeward areas off Oahu. Cruises and dates are given in table 1; the station locations are shown in figure 14. The six stations were sampled by making oblique hauls with a single open net at 0 to 60 m. Some of the data for this series were obtained from the comprehensive series.

Monthly Variations

Average adjusted volumes and standard deviations for collections of zooplankton in the monitor series are shown in figure 15. The lower panel, which includes data from both the windward and leeward stations, shows three peaks: a winter peak, probably in January; a spring peak in April; and a fall peak in September. Only the September peak is strongly defined, although the standard deviation is large. This variation is in contrast to the monthly average volumes computed by King and Hida (1957),

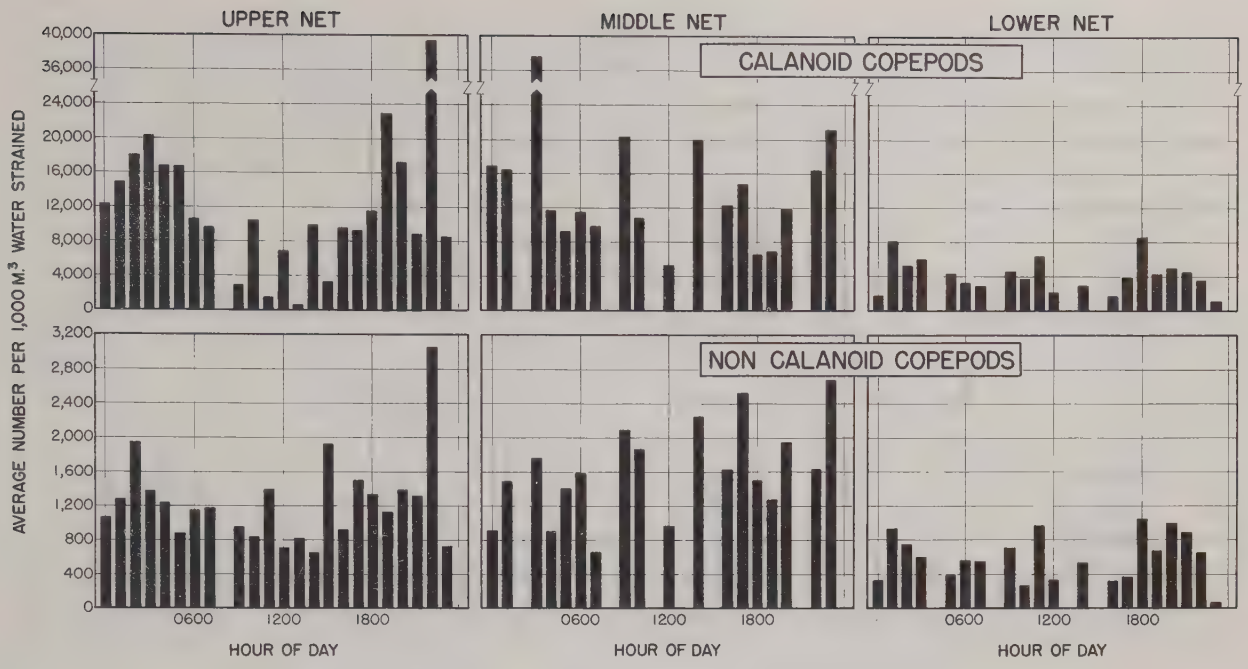

Figure 10.--Average number of calanoid and noncalanoid copepods per 1,000 m.^{3} of water strained by the three nets on HMS-32 and 34.

which increased from March to July and were variable thereafter. In the comprehensive series the highest averages were obtained during February and August on both the windward and the leeward sides (see tables 4 and 7). These differences are not surprising in view of the high variance that characterized the means for the different cruises.

Comparisons of Plankton in Windward and Leeward Samples

The only difference in distribution of zooplankton in windward and leeward areas was the time of the winter peak--January in windward and February in leeward stations (upper two panels of fig. 15). The adjusted grand averages for the windward and leeward areas were 22.9 and 20.3 cc./1,000 m.^{3} respectively (the difference was not significant).

INSHORE-OFFSHORE SERIES

To evaluate littoral influences on standing crops of zooplankton, an inshore and offshore station were designated in both the leeward and windward areas off Oahu. Because regular sampling in the windward area was prevented by unfavorable weather, data in this report are limited to those from the leeward stations (stations 1 and 3, about 5 and 25 miles [about 8 and 40 kilometers], respectively, from shore, fig. 15). These stations were sampled fairly regularly by vessels of the Bureau of Commercial Fisheries and by the vessel Makua of the Hawaii Division of Fish and Game (table 1). All samples were taken in oblique hauls with a single open net at 0 to 60 m. Some of the data for this series were obtained from the comprehensive and monitor series (appendix table 14).

The peaks in the curves showing semimonthly variations of adjusted volumes for the inshore and the offshore stations leeward of Oahu (fig. 16) coincide with those in the monitor series. This is a part-whole correlation, since these two stations are among the leeward and windward stations of the monitor series. King and Hida (1954) found that zooplankton was most abundant at a station 2 miles (3.2 kilometers) from shore and decreased from this point in both inshore and offshore directions.

The average adjusted volumes of zooplankton for the inshore and for the offshore stations were identical--17.1 cc./1,000 m.^{3}.

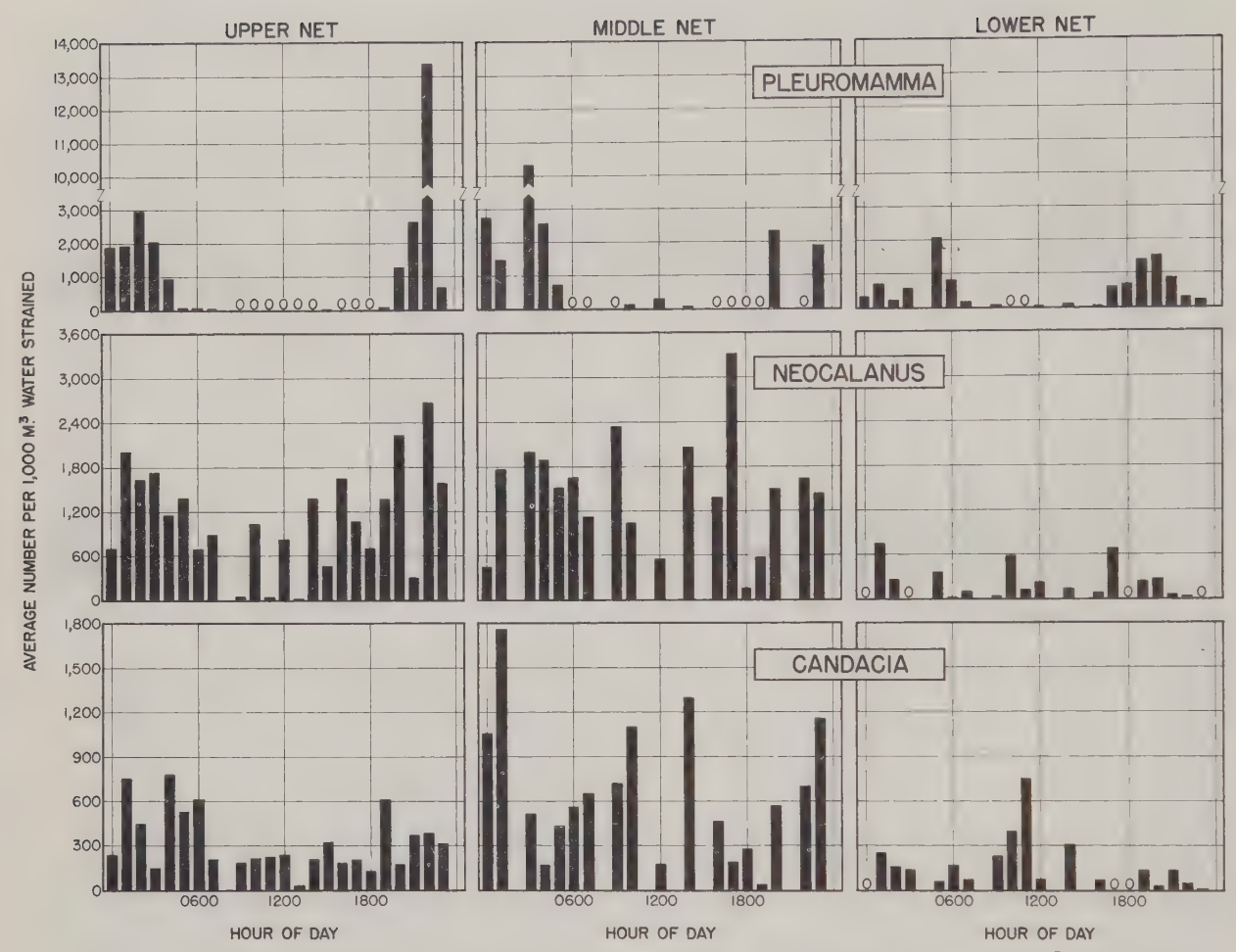

Figure 11.--Average number of Pleuromamma, Neocalanus, and Candacia per 1,000 m.^{3} of water strained by the three nets on HMS-34.

OBLIQUE HAULS AT 0 TO 200 M.

During HMS-34, hydrographic stations at which zooplankton was collected were occupied on April 27 to May 7 and June 20-28, 1956 (fig. 17). At each station, a 1/2-hour oblique haul was made at 0 to 200 m. with an open 1-m. net. Collections were compared with those from tows made at the same depths on CHG-24 (fig. 1) in November 1955.

The data for this series are presented in tables 15, 16, and 17 in the appendix. The average adjusted volume (cc. per 1,000 m.^{3}) was 14.0 for the April-May stations and 15.4 for the June stations of HMS-34; for the hauls at 0 to 200 m. during CHG-24 in November 1955, it was 12.4. The data from HMS-34 and CHG-24 are for different years and localities and therefore are not strictly comparable. As compared with the averages from similar tows for previous years (King and Hida, 1957; their fig. 7), the averages for 1955 and 1956 were among the lowest recorded for this type of tow (fig. 18).

SUMMARY

1. This report presents the results of a study of the abundance and distribution of zooplankton in Hawaiian waters in 1955-56. Collections were obtained on eight cruises by vessels of the Bureau of Commercial Fisheries and nine cruises by the vessel Makua of the Hawaii Division of Fish and Game.

2. Two types of sampling gear were used: three nets towed simultaneously at 0 to 60 m., 70 to 130 m., and 140 to 200 m. (the middle and lower nets had opening and closing devices), and a single net (of the same type as the upper

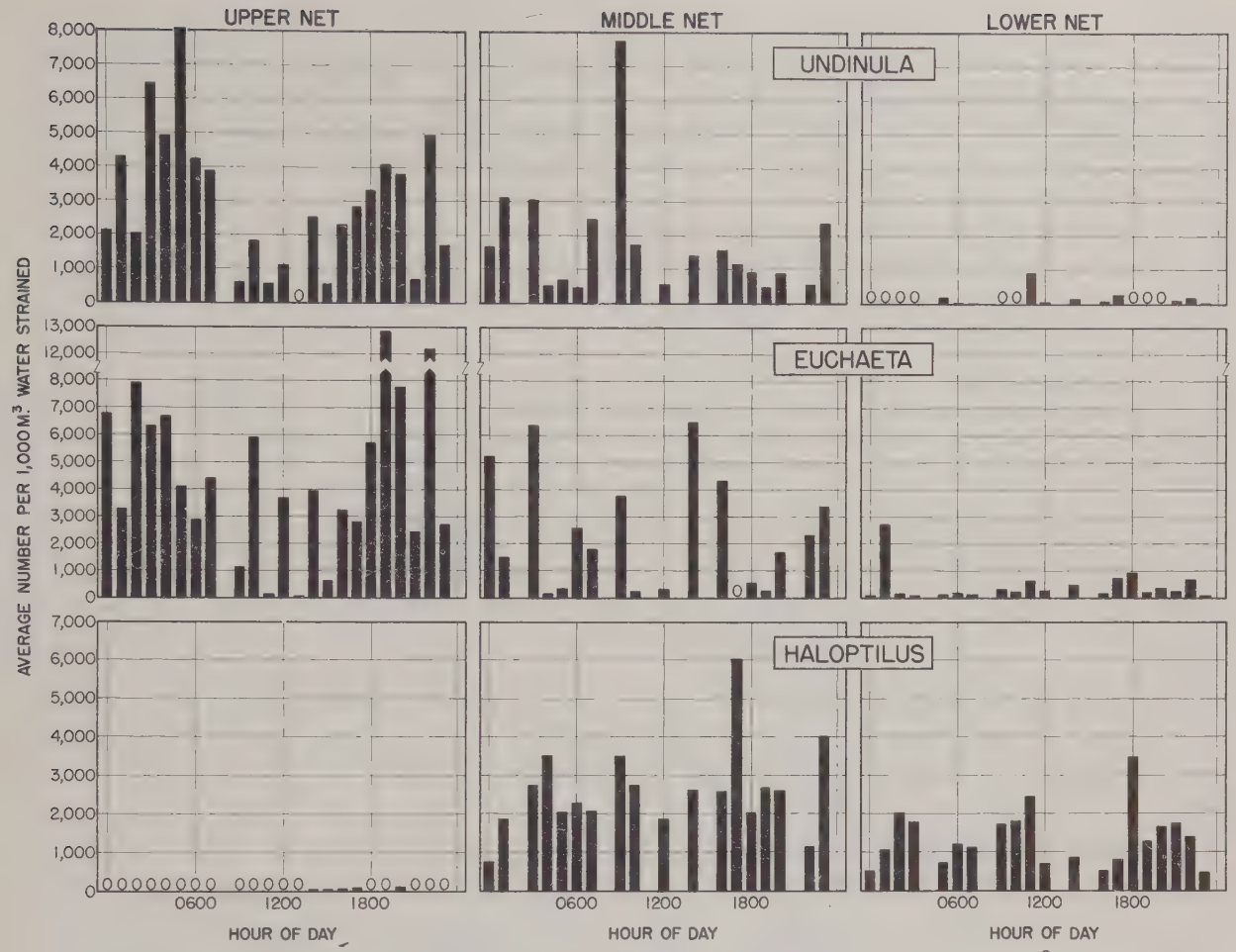

Figure 12.--Average number of Undinula, Euchaeta, and Haloptilus per 1,000 m.^{3} of water strained by the three nets on HMS-34.

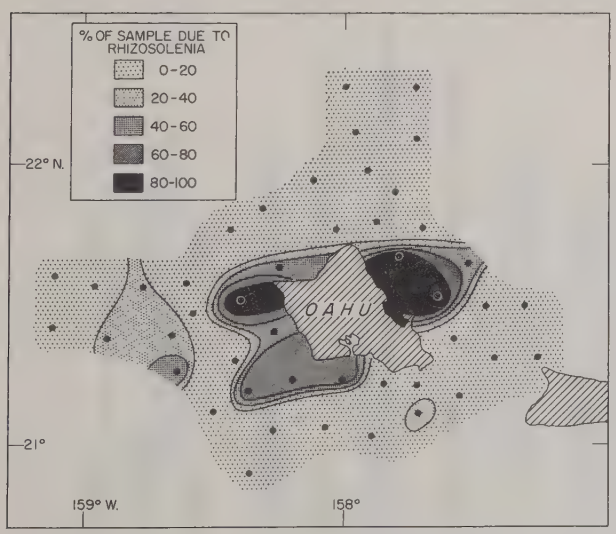

Figure 13.--Distribution and abundance of the diatom Rhizosolenia sp. around Oahu, August 1-6, 1956 (HMS-35).

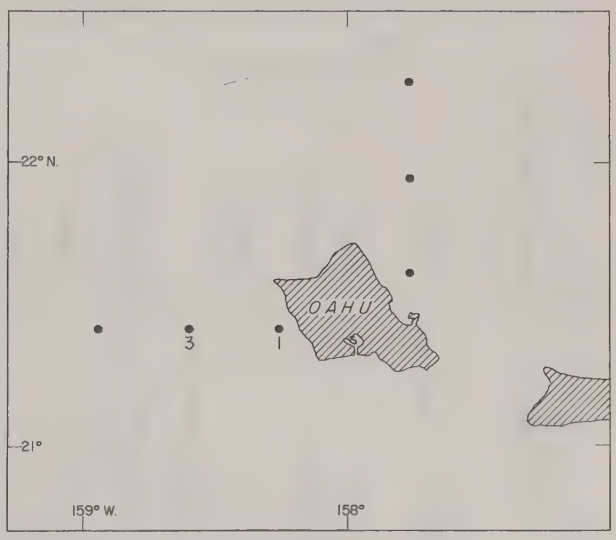

Figure 14.--Stations for collecting zooplankton for monitor series. Semimonthly collections were made at stations 1 and 3 for the inshore-offshore series.

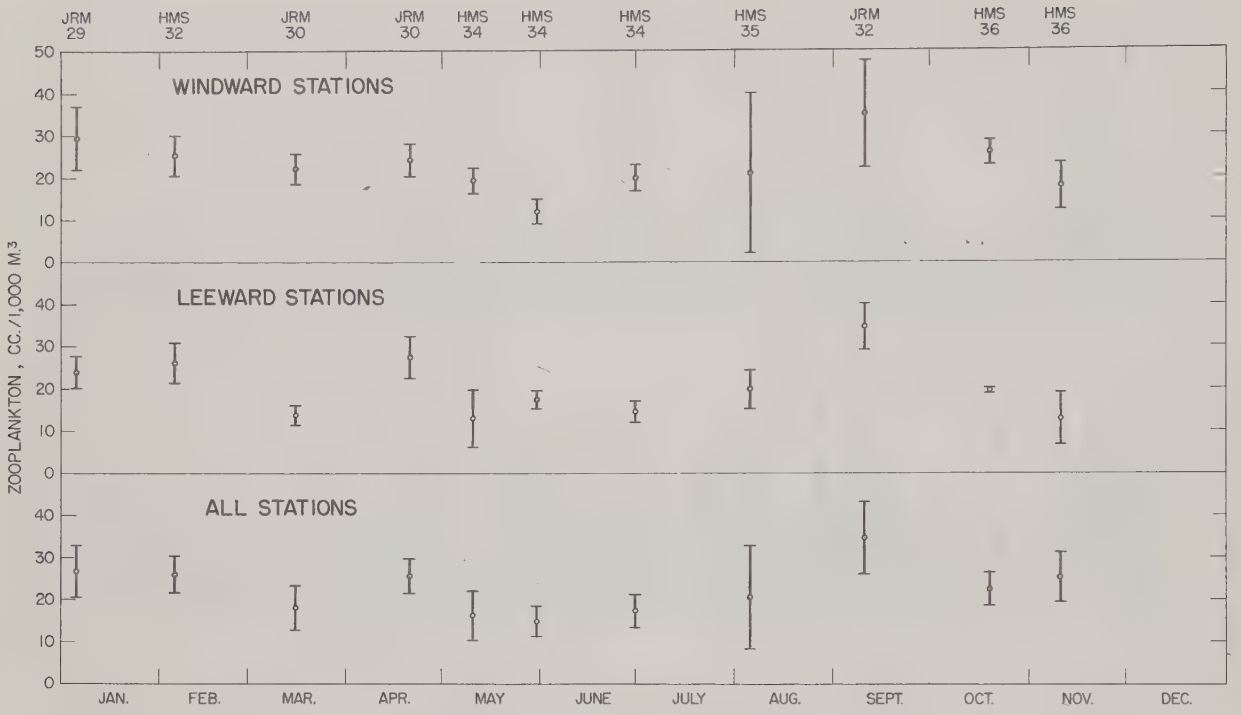

Figure 15.--Average adjusted volumes of zooplankton (points) ±1 standard deviation (vertical lines) for the monitor series, 1956.

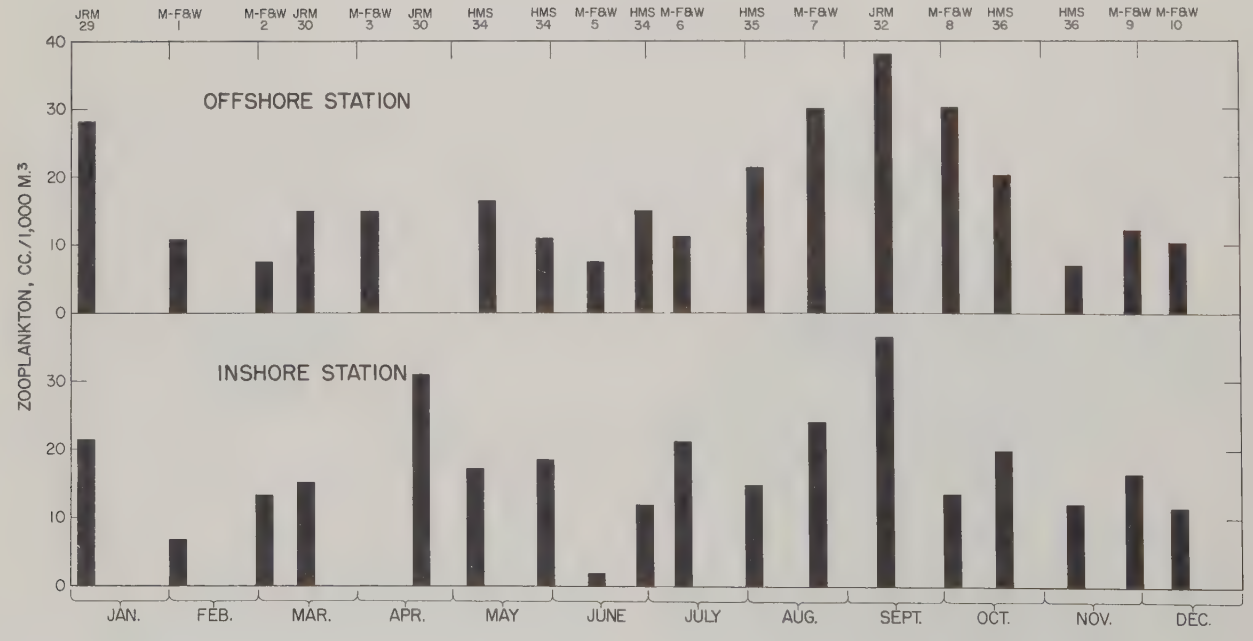

Figure 16.--Adjusted volumes of zooplankton for the inshore and offshore stations, 1956.

net in the three-net series). All nets had a mouth diameter of 1 m.

3. Sine-time adjustments for variations in volumes of zooplankton due to diel variation were made whenever possible. Corrections were applied to the sampling depths in the three-net hauls by the use of correction factors computed from depth-gage data.

4. Zooplankton in the upper stratum of water was, with one exception, greater in volume and number of organisms than in the middle and lower strata, regardless of the date or time of day.

5. Differences in average volumes of zooplankton between windward and leeward areas off Oahu were significant for the surface-to-thermocline hauls of CHG-24 (November 14-18, 1955) and for the upper nets of HMS-34 (May 7-29, 1956). Differences between areas were not significant for the middle and lower nets.

6. Seasonal catches appeared to be different, but their significance was clouded by some evidence of annual variations.

7. Copepods composed nearly one-half of all the organisms in the samples of zooplankton.

8. The relative abundance of the various groups of zooplankton remained comparatively stable by depth and season.

9. Decapod crustaceans were consistently more abundant on the windward side than on the leeward.

10. Halosphaera viridis, a planktonic alga, was very abundant at times. It made up 16 percent of the total number of organisms in one set of samples in the upper stratum of water.

11. The following groups exhibited conspicuous diel variations in abundance: polychaetes, ostracods, calanoid copepods, euphausiids, amphipods, pteropods, and fish larvae.

Figure 17.--Hydrographic stations at which zooplankton was collected on HMS-34.

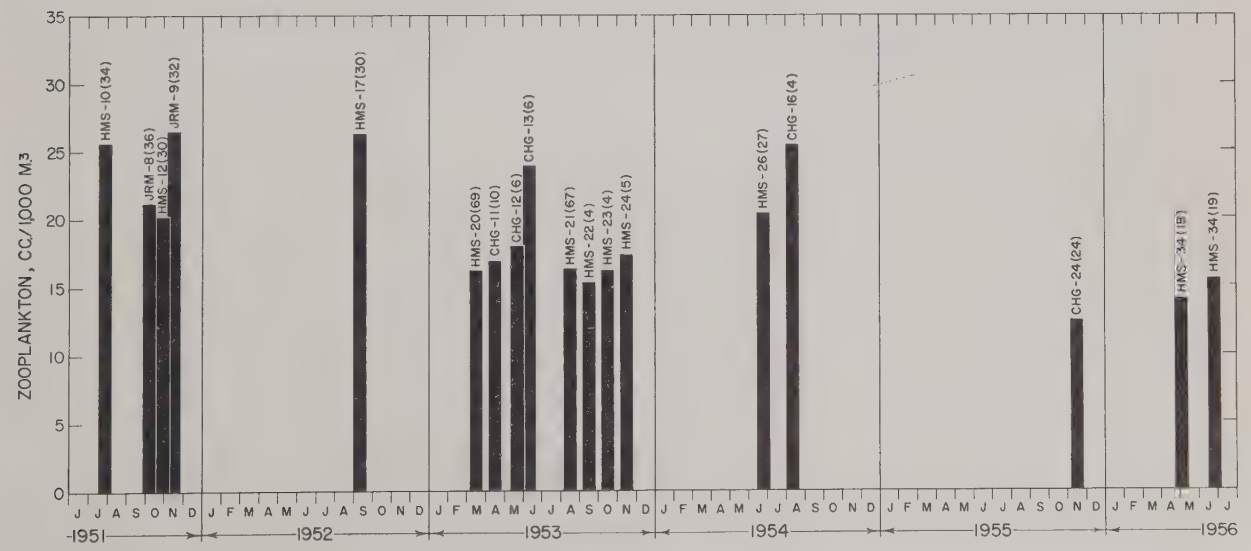

Figure 18.--Average volumes of zooplankton by cruise for each month in which samples were collected, July 1951 to June 1956. Number of samples is shown in parentheses. (Data for 1951-54 from fig. 7 in King and Hida, 1957.)

12. Of the calanoid Copepoda the abundance of the following genera exhibited the most marked diel variation: Pleuromamma, Neocalanus, Candacia, Undinula, and Euchaeta. The genus Haloptilus was absent from the upper layer of water.

13. An unusual bloom of a diatom, Rhizosolenia sp., was encountered August 1-6, 1956.

14. Average volumes from monthly samples of zooplankton from three stations on the windward side of Oahu and from three stations on the leeward side did not differ significantly. The data yielded indications of seasonal peaks in January, April, and September.

15. The average volumes of zooplankton at an inshore station 5 miles (8 kilometers) from shore and an offshore station 25 miles (40 kilometers) from shore did not differ.

16. The volumes of zooplankton from oblique hauls to a depth of 200 m. in 1955-56 were among the lowest recorded for this type of haul during 1951-56.

ACKNOWLEDGMENTS

Elbert H. Ahlstrom offered constructive criticisms of the manuscript, Everet C. Jones aided in identifying copepods, and Maxwell S. Doty identified the phytoplankton.

LITERATURE CITED

CUSHING, D. H.
1951. The vertical migration of plankton Crustacea. Biol. Rev. 26(2): 158-192.

HIDA, THOMAS S., and JOSEPH E. KING.
1955. Vertical distribution of zooplankton in the central equatorial Pacific, July-August 1952. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 144, iv + 22 p.

KIKUCHI, KENZO.
1930. Diurnal migrations of plankton Crustacea. Quart. Rev. Biol. 5(2): 189-206.

KING, JOSEPH E., THOMAS S. AUSTIN, and MAXWELL S. DOTY.
1957. Preliminary report on expedition Eastropic. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 201, iv + 155 p.

KING, JOSEPH E., and JOAN DEMOND.
1953. Zooplankton abundance in the central Pacific. U.S. Fish Wildl. Serv., Fish. Bull. 54: 111-144.

KING, JOSEPH E., and THOMAS S. HIDA.
1954. Variations in zooplankton abundance in Hawaiian waters. 1950-52. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 118, v + 66 p.
1957. Zooplankton abundance in Hawaiian waters, 1953-54. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 221, v + 23 p.

MILLER, S. M., H. B. MOORE, and K. R. KVAMMEN.
1953. Plankton of the Florida Current. I. General conditions. Bull. Mar. Sci. Gulf Caribbean 2(3): 465-485.

SNEDECOR, GEORGE W.
1956. Statistical methods. Fifth ed. Iowa State College Press, Ames, xiii + 534 p.

WELCH, PAUL S.
1948. Limnological methods. Blakiston Co., Philadelphia, xviii + 381 p.

APPENDIX TABLES

Appendix table 1.--Volumes of zooplankton collected at the odd-numbered stations on CHG-24, November 1955. All hauls were oblique tows with open nets between the surface and the indicated depths

Station	Position		Date	Time[1/]		Water strained	Depth	Zooplankton volume	
	N. Lat.	W. Long.		Start Hour	End Hour	$m.^3$	m.	Sample volume cc./1,000 $m.^3$	Sample volume cc./1,000 $m.^3$
1	21°17'	158°14'	11/14/55	1837	1859	1641.6	50	30.8	31.6
3	21°19'	158°26'	11/15/55	0000	0022	1059.7	55	28.3	22.0
5	21°32'	158°20'	11/15/55	0455	0515	1192.3	70	25.7	22.6
7	21°24'	158°40'	11/15/55	0922	0946	1562.3	65	15.2	17.9
9	21°36'	158°57'	11/15/55	1533	1601	1951.2	75	12.2	14.8
11	21°43'	158°26'	11/15/55	2124	2144	1250.9	65	27.2	23.1
13	21°40'	158°11'	11/16/55	0119	0145	1321.6	65	16.9	13.1
15	21°54'	158°05'	11/16/55	0612	0635	1463.1	65	9.4	9.0
17	21°47'	157°56'	11/16/55	1000	1018	721.9	65	11.1	13.3
19	22°06'	157°56'	11/16/55	1353	1415	1024.2	100	13.6	17.4
21	22°16'	157°44'	11/16/55	1801	1828	1521.4	85	15.6	16.3
23	21°50'	157°45'	11/16/55	2214	2236	1139.3	105	32.4	26.7
25	21°38'	157°48'	11/17/55	0117	0138	1160.3	90	20.2	15.6
27	21°40'	157°34'	11/17/55	0440	0508	1561.4	100	11.3	9.9
29	21°31'	157°40'	11/17/55	0806	0829	1081.0	70	7.9	8.6
31	21°28'	157°28'	11/17/55	1114	1143	1397.1	105	11.0	14.2
33	21°21'	157°36'	11/17/55	1420	1441	1107.6	55	17.2	21.7
35	21°11'	157°33'	11/17/55	1710	1734	1355.7	85	49.8	55.5
37	21°10'	157°45'	11/17/55	2016	2036	940.7	80	29.4	26.9
39	21°03'	157°48'	11/17/55	2303	2319	677.8	70	20.8	16.5
41	21°12'	157°54'	11/18/55	0152	0210	763.7	80	24.6	19.2
43	21°03'	158°01'	11/18/55	0524	0550	1371.1	90	18.2	16.7
45	21°14'	158°05'	11/18/55	0908	0936	1530.3	90	12.8	14.8
47	21°06'	158°14'	11/18/55	1224	1247	1039.0	105	19.2	24.8

[1/] Local civil time corresponding to +10 zone time.

Appendix table 2.--Volumes of zooplankton collected by the upper net on HMS-32, February 1956. All hauls were oblique tows with open nets down to the indicated depths

Station	Position		Date	Time[1/]		Water strained	Corrected depth	Zooplankton volume	
	N. Lat.	W. Long.		Start Hour	End Hour	$m.^3$	m.	Sample volume cc./1,000 $m.^3$	Adjusted volume cc./1,000 $m.^3$
1	21°11'	157°51'	2/2/56	1456	1526	1473.7	54	26.7	32.4
2	21°04'	157°45'	2/2/56	1714	1749	1351.5	57	6.7	7.3
3	21°02'	157°58'	2/2/56	1955	2025	1193.9	45	9.3	8.8
5	21°15'	158°11'	2/3/56	0425	0458	1672.3	54	17.4	15.2
6	21°03'	158°09'	2/3/56	0709	0739	1229.8	52	22.1	22.5
7	20°56'	158°18'	2/3/56	0955	1025	1275.0	48	12.2	14.4
8	21°04'	158°29'	2/3/56	1248	1319	1090.4	56	15.0	19.0
9	21°10'	158°20'	2/3/56	1503	1534	1207.4	52	26.1	31.6
10	21°19'	158°14'	2/3/56	1721	1750	1490.6	40	22.7	24.6
11	21°18'	158°26'	2/3/56	1952	2022	1343.7	52	23.3	21.9
12	21°12'	158°35'	2/3-4/56	2359	0029	1310.9	55	29.1	23.1
13	21°24'	158°41'	2/4/56	0240	0312	1088.4	46	25.5	20.8
14	21°22'	158°52'	2/4/56	0525	0555	1080.0	48	25.8	23.8
15	21°22'	159°02'	2/4/56	0814	0844	1335.9	52	13.1	14.2
16	21°36'	159°03'	2/4/56	1035	1105	1228.2	49	26.8	32.4
17	21°36'	158°53'	2/4/56	1227	1258	1348.9	54	22.0	27.7
18	21°35'	158°43'	2/4/56	1445	1515	991.9	55	19.0	23.3
19	21°36'	158°32'	2/4/56	1638	1707	808.6	52	18.4	20.7
20	21°26'	158°31'	2/4/56	1850	1919	1253.7	49	29.4	29.4
21	21°30'	158°22'	2/4/56	2210	2240	1505.1	47	28.1	23.5
22	21°39'	158°14'	2/5/56	0112	0139	1113.8	47	24.3	19.3
23	21°46'	158°25'	2/5/56	0345	0415	1042.6	55	19.1	16.2
24	21°50'	158°18'	2/5/56	0533	0602	997.9	52	20.5	18.9
25	21°46'	158°08'	2/5/56	0735	0806	1370.5	49	14.7	15.6
26	21°55'	158°08'	2/5/56	0936	1002	1449.5	52	26.1	30.4
27	21°58'	157°54'	2/5/56	1140	1209	1481.5	49	9.6	12.0
28	22°06'	157°52'	2/5/56	1403	1432	1351.0	52	21.9	27.3
29	22°14'	157°58'	2/5/56	1603	1633	1150.2	55	26.4	30.8
30	22°15'	157°46'	2/5/56	1755	1825	1549.1	50	26.0	27.6
31	22°06'	157°44'	2/5/56	2003	2033	1433.1	69	36.8	34.0
32	21°51'	157°42'	2/5/56	2326	2357	1435.7	49	38.9	31.2
33	21°45'	157°52'	2/6/56	0121	0153	1225.1	62	34.4	27.4
34	21°37'	157°49'	2/6/56	0317	0344	1031.2	43	28.5	23.8
35	21°46'	157°40'	2/6/56	0520	0548	1408.2	46	29.8	27.5
36	21°38'	157°32'	2/6/56	0731	0801	1372.3	55	20.0	20.8
37	21°32'	157°42'	2/6/56	1008	1041	1530.9	53	15.0	17.9
38	21°30'	157°26'	2/6/56	1249	1317	1187.7	48	28.0	35.1
39	21°30'	157°16'	2/6/56	1430	1459	1415.4	52	18.7	22.4
40	21°20'	157°12'	2/6/56	1613	1641	1132.0	55	22.3	24.6
42	21°20'	157°34'	2/6/56	2205	2235	1037.0	52	37.0	30.9
43	21°13'	157°43'	2/7/56	0200	0230	1081.1	59	35.0	28.1
44	21°11'	157°31'	2/7/56	0335	0404	1306.2	52	29.0	24.2
45	21°05'	157°41'	2/7/56	0536	0609	1147.6	43	21.3	20.0

[1/] Local civil time corresponding to +10 zone time.

Appendix table 3.--Volumes of zooplankton collected by the upper net on HMS-34, May 1956. All hauls were oblique tows with open nets down to the indicated depths

Station	Position		Date	Time[1]		Water strained	Corrected depth[2]	Zooplankton volume	
	N. Lat.	W. Long.		Start Hour	End Hour	$m.^3$	m.	Sample volume $cc./1,000\ m.^3$	Adjusted volume $cc./1,000\ m.^3$
P1-53	21°09'	157°52'	5/10/56	0511	0542	1752.3	59	14.8	10.4
P2-54	21°03'	157°51'	5/10/56	0655	0725	1969.9	52	10.1	10.1
P3-55	21°04'	157°57'	5/10/56	0920	0950	1815.4	35	5.8	9.9
P4-56	21°15'	157°57'	5/10/56	1120	1151	1635.7	43	3.7	8.1
P5-57	21°05'	158°13'	5/10/56	1409	1439	2462.4	30	3.0	6.6
P6-58	20°59'	158°23'	5/10/56	1614	1644	1501.0	46	7.2	12.3
P7-59	21°04'	158°26'	5/10/56	1809	1840	1884.0	38(?)	13.0	15.0
P8-60	21°14'	158°20'	5/10/56	2007	2038	1401.3	38	50.6	38.0
P9-61	21°14'	158°13'	5/10/56	2126	2157	1915.7	30	14.6	8.5
P10-62	21°19'	158°19'	5/11/56	0006	0037	2028.2	43	32.5	14.3
P11-63	21°16'	158°26'	5/11/56	0137	0207	1615.6	52	28.0	12.5
P12-64	21°11'	158°35'	5/11/56	0357	0427	1241.4	48	32.1	18.7
P13-65	21°21'	158°41'	5/11/56	0621	0652	1980.8	35	8.6	8.0
P14-66	21°21'	158°52'	5/11/56	0854	0925	2004.5	35	3.7	5.6
P15-22	21°25'	159°05'	5/7/56	0632	0702	1988.5	46	10.3	9.6
P16-23	21°35'	159°03'	5/7/56	0900	0930	2092.1	35	2.2	3.6
P17-24	21°35'	158°54'	5/7/56	1052	1122	1462.8	43	4.6	9.5
P18-25	21°34'	158°43'	5/7/56	1256	1327	1942.9	42	1.4	3.2
P19-26	21°35'	158°33'	5/7/56	1458	1537	1687.5	59	6.0	11.9
P20-27	21°26'	158°31'	5/7/56	1712	1742	1653.5	55	12.6	17.9
P21-28	21°33'	158°25'	5/7/56	1900	1929	1482.7	43	50.0	46.5
P22-29	21°42'	158°15'	5/7/56	2223	2253	1259.8	43	53.5	26.9
P23-30	21°46'	158°23'	5/8/56	0105	0136	1677.7	43	26.0	11.3
P24-31	21°51'	158°14'	5/8/56	0307	0338	1674.8	52	26.3	13.2
P25-32	21°53'	158°05'	5/8/56	0507	0538	1562.9	59	18.1	12.7
P26-33	21°44'	158°07'	5/8/56	0725	0755	1318.4	55	11.1	12.8
P27-34	21°51'	157°53'	5/8/56	1001	1030	1720.4	46	7.7	14.6
P28-35	22°02'	157°56'	5/8/56	1219	1251	1779.0	43	13.5	31.0
P29-36	22°07'	157°55'	5/8/56	1352	1421	1586.6	43	18.1	40.6
P30-37	22°15'	157°53'	5/8/56	1548	1618	1575.0	52	13.3	24.0
P31-38	22°15'	157°45'	5/8/56	1733	1804	1520.8	52	18.1	24.1
P32-39	22°02'	157°44'	5/8/56	1959	2029	1549.3	52	24.3	18.3
P33-40	21°51'	157°45'	5/8/56	2304	2336	1903.3	43	34.3	16.1
P34-41	21°44'	157°38'	5/9/56	0109	0139	1381.7	55	32.4	14.1
P35-42	21°39'	157°42'	5/9/56	0353	0425	1814.5	52	26.2	14.5
P36-43	21°33'	157°39'	5/9/56	0537	0608	1613.2	43	13.8	11.1
P37-44	21°38'	157°32'	5/9/56	0726	0757	1336.1	55	19.3	22.3
P38-45	21°29'	157°26'	5/9/56	1000	1031	1601.1	43	9.5	20.3
P39-46	21°28'	157°11'	5/9/56	1210	1240	1589.5	43	4.8	11.0
P40-47	21°19'	157°09'	5/9/56	1409	1442	1382.0	52	10.9	21.6
P41-48	21°20'	157°25'	5/9/56	1648	1718	1285.2	52	8.8	10.9
P42-49	21°22'	157°32'	5/9/56	1843	1916	1502.2	46	11.8	11.8
P43-50	21°13'	157°30'	5/9/56	2235	2306	1611.1	43	11.0	4.9
P44-51	21°13'	157°40'	5/10/56	0059	0134	1335.0	48	19.3	8.4
P45-52	21°05'	157°42'	5/10/56	0302	0332	1524.1	52	15.1	7.6

[1] Local civil time corresponding to +10 zone time.

[2] Question mark indicates estimated depth due to insufficient data.

Appendix table 4.--Volumes of zooplankton collected by the upper net on HMS-35, August 1956. All hauls were oblique tows with open nets down to the indicated depths

Station	Position		Date	Time[1/]		Water strained	Corrected depth	Zooplankton volume	
	N. Lat.	W. Long.		Start Hour	End Hour	$m.^3$	m.	Sample volume cc./1,000 $m.^3$	Adjusted volume cc./1,000 $m.^3$
1	21°13'	157°51'	8/1/56	1916	1949	2206.6	48	38.3	35.1
2	21°02'	157°54'	8/1/56	2240	2312	1720.9	52	26.2	16.9
3	21°04'	158°04'	8/2/56	0132	0203	1231.9	43	24.4	14.8
4	21°14'	158°00'	8/2/56	0418	0451	1910.5	48	16.1	12.1
5	21°03'	158°16'	8/2/56	0721	0752	1610.7	43	15.6	17.0
6	20°54'	158°22'	8/2/56	1020	1056	2078.1	43	14.4	21.7
7	21°07'	158°30'	8/2/56	1316	1349	1652.7	48	12.8	21.0
8	21°12'	158°22'	8/2/56	1511	1541	1641.4	46	9.1	13.7
9	21°14'	158°12'	8/2/56	1727	1801	1615.3	48	12.1	14.4
10	21°24'	158°16'	8/2/56	2007	2036	1500.5	45	18.5	15.6
11	21°18'	158°25'	8/2-3/56	2340	0010	1573.8	48	18.4	11.3
12	21°16'	158°38'	8/3/56	0226	0256	1437.8	52	21.3	13.5
13	21°24'	158°39'	8/3/56	0451	0522	1216.8	43	27.0	20.9
14	21°23'	158°54'	8/3/56	0731	0801	1088.1	43	21.0	22.9
15	21°25'	159°06'	8/3/56	1010	1041	1458.1	45	9.5	14.0
16	21°36'	159°06'	8/3/56	1215	1245	1990.6	38	10.0	16.4
17	21°34'	158°57'	8/3/56	1426	1455	1422.2	43	18.0	28.4
18	21°34'	158°46'	8/3/56	1638	1709	1599.6	55	13.8	17.8
19	21°35'	158°36'	8/3/56	1829	1900	1519.6	45	18.3	19.1
20	21°28'	158°35'	8/3/56	2033	2103	1557.9	46	28.4	22.9
21	21°31'	158°24'	8/3/56	2328	2359	1698.8	45	8.0	5.0
22	21°38'	158°15'	8/4/56	0202	0232	1371.7	52	22.4	13.9
23	21°46'	158°26'	8/4/56	0432	0502	1492.9	52	43.1	32.2
24	21°50'	158°19'	8/4/56	0620	0653	1359.5	43	28.5	27.3
25	21°56'	158°07'	8/4/56	0836	0906	1525.4	46	12.1	15.6
26	21°46'	158°02'	8/4/56	1104	1136	1645.5	43	10.6	16.7
27	21°48'	157°53'	8/4/56	1249	1319	1128.1	43	14.4	23.8
28	21°58'	157°55'	8/4/56	1557	1626	1428.0	54	16.5	22.8
29	22°06'	157°58'	8/4/56	1742	1814	1579.0	56	14.6	16.6
30	22°16'	158°00'	8/4/56	1943	2014	1693.0	43	19.6	17.2
31	22°16'	157°48'	8/4-5/56	2354	0026	1492.9	52	29.5	18.1
32	22°05'	157°48'	8/5/56	0255	0327	1780.0	52	42.0	27.8
33	21°54'	157°49'	8/5/56	0516	0548	1332.3	43	52.2	44.0
34	21°46'	157°43'	8/5/56	0714	0746	1467.1	43	10.9	11.4
35	21°40'	157°48'	8/5/56	0930	1000	1647.2	43	3.3	4.6
36	21°32'	157°39'	8/5/56	1131	1201	1300.4	52	8.3	13.3
37	21°39'	157°32'	8/5/56	1355	1426	1305.0	48	20.5	33.0
38	21°30'	157°28'	8/5/56	1605	1635	1403.0	52	16.9	20.9
39	21°30'	157°19'	8/5/56	1745	1815	1690.1	43	16.2	16.2
40	21°19'	157°16'	8/5/56	2005	2033	1167.8	43	49.4	37.0
41	21°19'	157°26'	8/5/56	2230	2303	1208.1	46	47.0	29.2
42	21°23'	157°35'	8/6/56	0107	0138	1501.6	46	44.4	26.9
43	21°11'	157°34'	8/6/56	0332	0405	1403.6	43	35.2	23.9
44	21°13'	157°43'	8/6/56	0630	0702	1497.0	46	17.2	16.5
45	21°07'	157°43'	8/6/56	0826	0900	1563.4	43	24.2	30.0

[1/] Local civil time corresponding to +10 zone time.

Appendix table 5.--Volumes of zooplankton collected by the upper net on HMS-36, November 1956. All hauls were oblique tows with open nets down to the indicated depths

Station	Position		Date	Time[1/]		Water strained	Corrected depth	Zooplankton volume	
	N. Lat.	W. Long.		Start Hour	End Hour	$m.^3$	m.	Sample volume $cc./1,000\ m.^3$	Adjusted volume $cc./1,000\ m.^3$
1	21°11'	157°53'	11/10/56	1716	1744	1472.4	50	10.2	12.4
2	21°05'	157°54'	11/10/56	1550	1620	1426.1	62	6.7	9.3
3	21°05'	158°04'	11/10/56	1411	1441	1413.5	56	12.7	19.6
4	21°15'	157°59'	11/10/56	1833	1857	1221.5	46	17.0	17.7
5	21°06'	158°15'	11/10/56	1231	1302	1426.4	74	9.3	14.7
6	20°57'	158°21'	11/10/56	1049	1119	1533.5	55	9.3	13.9
8	21°13'	158°19'	11/10/56	0721	0747	1102.0	46	22.2	24.0
9	21°18'	158°14'	11/10/56	0552	0621	1357.5	53	19.2	17.0
10	21°22'	158°18'	11/10/56	0430	0502	1711.9	53	17.4	13.4
11	21°20'	158°28'	11/10/56	0307	0337	1500.4	53	22.3	15.2
12	21°16'	158°34'	11/10/56	0157	0227	1255.2	62	16.6	10.7
13	21°23'	158°38'	11/10/56	0018	0048	1786.2	53	13.6	8.6
14	21°24'	158°53'	11/9/56	2213	2242	1425.6	56	31.5	22.1
15	21°25'	159°03'	11/9/56	1928	1958	1341.5	56	28.3	26.1
16	21°34'	159°06'	11/9/56	1743	1813	1287.3	53	23.3	20.7
17	21°35'	158°56'	11/9/56	1555	1626	1356.4	56	16.4	22.1
18	21°36'	158°46'	11/9/56	1357	1426	1407.8	64	14.8	22.9
19	21°40'	158°35'	11/9/56	1152	1225	1645.3	53	11.5	18.0
20	21°30'	158°29'	11/9/56	1020	1054	1608.0	48	12.9	18.9
21	21°36'	158°22'	11/9/56	0836	0909	1711.1	46	9.9	12.5
22	21°40'	158°15'	11/9/56	0644	0715	1519.1	55	10.9	10.9
23	21°46'	158°24'	11/9/56	0519	0549	1608.8	46	20.0	17.1
24	21°50'	158°14'	11/9/56	0349	0418	1657.6	53	29.9	21.6
25	21°55'	158°07'	11/9/56	0221	0251	1520.9	56	31.6	20.8
26	21°46'	158°06'	11/9/56	0100	0131	1523.5	62	26.3	16.6
27	21°48'	157°56'	11/8/56	2318	2350	1602.1	53	36.6	23.7
28	21°57'	157°56'	11/8/56	2144	2216	1562.6	62	26.6	19.2
29	22°06'	157°56'	11/8/56	2011	2041	1488.5	48	17.3	14.8
30	22°14'	157°55'	11/8/56	1849	1917	1545.1	71	22.4	22.4
31	22°12'	157°45'	11/8/56	1655	1724	1656.6	46	17.2	21.7
32	22°04'	157°46'	11/8/56	1525	1554	1661.8	44	12.9	18.4
33	21°53'	157°47'	11/8/56	1346	1414	1784.6	44	6.8	10.6
34	21°45'	157°42'	11/8/56	1157	1227	1603.4	53	6.5	10.3
35	21°37'	157°48'	11/8/56	1045	1113	1463.9	53	9.8	14.6
36	21°32'	157°40'	11/8/56	0843	0913	1307.1	66	9.0	11.3
37	21°39'	157°32'	11/8/56	0651	0720	1471.6	53	9.4	9.4
38	21°31'	157°27'	11/8/56	0518	0547	1395.5	50	9.8	9.4
39	21°29'	157°19'	11/8/56	0345	0414	1316.4	48	17.2	13.7
40	21°19'	157°14'	11/8/56	0205	0235	1494.7	42	22.3	15.2
41	21°20'	157°24'	11/8/56	0020	0051	1443.1	53	18.2	11.5
42	21°23'	157°35'	11/7/56	2245	2315	1393.5	53	15.2	10.2
43	21°10'	157°31'	11/7/56	2039	2113	1654.6	55	17.3	13.7
44	21°12'	157°42'	11/7/56	1904	1926	1075.3	53	13.1	12.6
45	21°06'	157°42'	11/7/56	1749	1806	881.8	56	9.1	10.3

[1/] Local civil time corresponding to +10 zone time.

Appendix table 6.--Volumes of zooplankton collected by the middle net on HMS-32, February 1956. All hauls were oblique tows with closing nets between the indicated depths

Station	Position		Date	Time[1]		Water strained	Corrected depth[2]	Sample volume
	N. Lat.	W. Long.		Start Hour	End Hour	$m.^3$	m.	cc./1,000 $m.^3$
1	21°11'	157°51'	2/2/56	1456	1526	576.9	63(?)-122	11.4
2	21°04'	157°45'	2/2/56	1714	1749	936.8	77 -141	8.3
4	21°12'	158°00'	2/3/56	0121	0154	1025.5	61 -133	19.2
5	21°15'	158°11'	2/3/56	0425	0458	813.2	57 -122	21.6
6	21°03'	158°09'	2/3/56	0709	0739	796.1	65(?)-133	5.5
8	21°04'	158°29'	2/3/56	1248	1319	873.1	71 -135	10.5
9	21°10'	158°20'	2/3/56	1503	1534	918.7	57 -124	13.5
11	21°18'	158°26'	2/3/56	1952	2022	1319.5	48(?)-118	19.1
12	21°12'	158°35'	2/3-4/56	2359	0029	885.8	61(?)-132	23.3
13	21°24'	158°41'	2/4/56	0240	0312	920.4	57(?)-112	13.7
14	21°22'	158°52'	2/4/56	0525	0555	863.6	50(?)-117	20.7
15	21°22'	159°02'	2/4/56	0814	0844	888.7	55(?)-124	9.2
17	21°36'	158°53'	2/4/56	1227	1258	541.0	67 -122	28.3
19	21°36'	158°32'	2/4/56	1638	1707	638.9	67(?)-124	14.1
20	21°26'	158°31'	2/4/56	1850	1919	1091.5	55(?)-121	16.9
21	21°30'	158°22'	2/4/56	2210	2240	1109.6	50(?)-109	23.1
22	21°39'	158°14'	2/5/56	0112	0139	666.8	67(?)-109	12.6
24	21°50'	158°18'	2/5/56	0533	0602	706.0	67(?)-124	16.7
26	21°55'	158°08'	2/5/56	0936	1002	1245.7	45(?)-118	23.8
27	21°58'	157°54'	2/5/56	1140	1209	1457.6	43(?)-113	15.8
28	22°06'	157°52'	2/5/56	1403	1432	1247.4	35 -124	20.2
29	22°14'	157°58'	2/5/56	1603	1633	594.2	61 -132	13.5
30	22°15'	157°46'	2/5/56	1755	1825	1028.2	43(?)-110	2.3
31	22°06'	157°44'	2/5/56	2003	2033	861.5	35(?)-151	7.7
32	21°51'	157°42'	2/5/56	2326	2357	536.4	35 -126	8.9
33	21°45'	157°52'	2/6/56	0121	0153	1087.1	45 -141	21.3
34	21°37'	157°49'	2/6/56	0317	0344	560.8	61(?)-114	26.4
35	21°46'	157°40'	2/6/56	0520	0548	1060.8	59 -112	15.2
36	21°38'	157°32'	2/6/56	0731	0801	1081.6	45(?)-125	1.6
37	21°32'	157°42'	2/6/56	1008	1041	1184.8	43 -114	19.7
38	21°30'	157°26'	2/6/56	1249	1317	1033.2	63 -117	10.6
39	21°30'	157°16'	2/6/56	1430	1459	1083.7	53 -124	46.0
41	21°19'	157°22'	2/6/56	1846	1919	1096.1	71(?)-121	17.9
42	21°20'	157°34'	2/6/56	2205	2235	596.7	69(?)-124	1.0
43	21°13'	157°43'	2/7/56	0200	0230	1628.6	45(?)-143	16.8
44	21°11'	157°31'	2/7/56	0335	0404	1386.8	45(?)-124	14.3
45	21°05'	157°41'	2/7/56	0536	0609	1228.2	45(?)-108	15.5

[1] Local civil time corresponding to +10 zone time.

[2] Question mark indicates estimated depth due to insufficient data.

Appendix table 7.--Volumes of zooplankton collected by the middle net on HMS-34, May 1956. All hauls were oblique tows with closing nets between the indicated depths

Station	Position		Date	Time[1]		Water strained	Corrected depth[2]	Sample volume
	N. Lat.	W. Long.		Start Hour	End Hour	$m.^3$	m.	cc./1,000 $m.^3$
P1-53	21°09'	157°52'	5/10/56	0511	0542	492.4	57 -143	7.9
P2-54	21°03'	157°51'	5/10/56	0655	0725	861.8	57(?)-124	17.3
P3-55	21°04'	157°57'	5/10/56	0920	0950	304.6	50(?)- 92	38.4
P6-58	20°59'	158°23'	5/10/56	1614	1644	369.1	50 -114	40.4
P7-59	21°04'	158°26'	5/10/56	1809	1840	863.1	50(?)- 93(?)	8.2
P8-60	21°14'	158°20'	5/10/56	2007	2038	1197.3	45(?)- 93	16.4
P10-62	21°19'	158°19'	5/11/56	0006	0037	792.9	48 -105	25.0
P13-65	21°21'	158°41'	5/11/56	0621	0652	865.0	35(?)- 85	19.5
P14-66	21°21'	158°52'	5/11/56	0854	0925	1092.1	45(?)- 85	13.1
P15-22	21°25'	159°05'	5/7/56	0632	0702	768.0	67 -112	16.1
P16-23	21°35'	159°03'	5/7/56	0900	0930	582.6	45(?)- 85	19.2
P21-28	21°33'	158°25'	5/7/56	1900	1929	365.3	57(?)-105	4.7
P22-29	21°42'	158°15'	5/7/56	2223	2253	1030.1	57(?)-105	18.3
P29-36	22°07'	157°55'	5/8/56	1352	1421	665.6	50 -105	9.0
P30-37	22°15'	157°53'	5/8/56	1548	1618	891.0	45 -124	8.5
P31-38	22°15'	157°45'	5/8/56	1733	1804	309.5	71 -124	23.9
P32-39	22°02'	157°44'	5/8/56	1959	2029	455.8	67 -124	19.5
P33-40	21°51'	157°45'	5/8/56	2304	2336	825.5	57(?)-105	24.6
P35-42	21°39'	157°42'	5/9/56	0353	0425	730.3	67 -124	15.7
P36-43	21°33'	157°39'	5/9/56	0537	0608	324.1	57 -105	14.2
P37-44	21°38'	157°32'	5/9/56	0726	0757	492.1	71(?)-132	11.4
P38-45	21°29'	157°26'	5/9/56	1000	1031	435.5	57(?)-105	11.0
P39-46	21°28'	157°11'	5/9/56	1210	1240	983.7	53 -105	8.8
P40-47	21°19'	157°09'	5/9/56	1409	1442	404.9	63 -124	34.1
P42-49	21°22'	157°32'	5/9/56	1843	1916	350.7	61(?)-112	10.6
P43-50	21°13'	157°30'	5/9/56	2235	2306	243.1	57(?)-105	36.2
P44-51	21°13'	157°40'	5/10/56	0059	0134	887.0	63 -117	31.1
P45-52	21°05'	157°42'	5/10/56	0302	0332	239.0	67 -124	41.8

[1] Local civil time corresponding to +10 zone time.

[2] Question mark indicates estimated depth due to insufficient data.

Appendix table 8.--Volumes of zooplankton collected by the middle net on HMS-35, August 1956. All hauls were oblique tows with closing nets between the indicated depths

Station	Position		Date	Time[1]		Water strained	Corrected depth[2]	Sample volume
	N. Lat.	W. Long.		Start Hour	End Hour	$m.^3$	m.	$cc./1{,}000\ m.^3$
1	21°13'	157°51'	8/1/56	1916	1949	300.6	35(?)-124	19.3
2	21°02'	157°54'	8/1/56	2240	2312	1171.8	57(?)-124(?)	16.2
3	21°04'	158°04'	8/2/56	0132	0203	1058.4	57 -105	21.9
4	21°14'	158°00'	8/2/56	0418	0451	641.8	77 -117	24.9
5	21°03'	158°16'	8/2/56	0721	0752	680.9	35 -105	12.2
6	20°54'	158°22'	8/2/56	1020	1056	1241.2	53 -105	12.6
7	21°07'	158°30'	8/2/56	1316	1349	966.8	57(?)-117	6.4
8	21°12'	158°22'	8/2/56	1511	1541	879.6	57 -112	8.5
9	21°14'	158°12'	8/2/56	1727	1801	1142.9	59(?)-124	7.1
10	21°24'	158°16'	8/2/56	2007	2036	530.6	45 -109	21.5
11	21°18'	158°25'	8/2-3/56	2340	0010	918.9	35 -117	2.0
12	21°16'	158°38'	8/3/56	0226	0256	617.0	67(?)-124	30.6
13	21°24'	158°39'	8/3/56	0451	0522	936.1	57(?)-108	17.8
14	21°23'	158°54'	8/3/56	0731	0801	1065.4	57(?)-105	9.0
15	21°25'	159°06'	8/3/56	1010	1041	1124.8	53(?)-109	9.8
16	21°36'	159°06'	8/3/56	1215	1245	698.8	45(?)-106	28.0
17	21°34'	158°57'	8/3/56	1426	1455	794.2	63(?)-109	18.4
18	21°34'	158°46'	8/3/56	1638	1709	965.9	71 -132	11.4
19	21°35'	158°36'	8/3/56	1829	1900	824.7	67 -109	8.0
20	21°28'	158°35'	8/3/56	2033	2103	1087.5	59 -114	11.3
21	21°31'	158°24'	8/3/56	2328	2359	836.2	53 -109	28.3
22	21°38'	158°15'	8/4/56	0202	0232	563.6	67(?)-124	9.6
23	21°46'	158°26'	8/4/56	0432	0502	743.5	67(?)-124	24.9
24	21°50'	158°19'	8/4/56	0620	0653	1154.4	57 -105	15.1
25	21°56'	158°07'	8/4/56	0836	0906	1114.2	39 -112	28.9
26	21°46'	158°02'	8/4/56	1104	1136	886.4	50 -105	17.5
27	21°48'	157°53'	8/4/56	1249	1319	957.8	67 -105	9.2
28	21°58'	157°55'	8/4/56	1557	1626	941.5	35(?)-127	33.6
29	22°06'	157°58'	8/4/56	1742	1814	882.3	50(?)-135	11.8
30	22°16'	158°00'	8/4/56	1943	2014	898.4	57 -105	19.0
31	22°16'	157°48'	8/4-5/56	2354	0026	752.1	63(?)-124	18.5
32	22°05'	157°48'	8/5/56	0255	0327	737.7	63(?)-124	14.1
33	21°54'	157°49'	8/5/56	0516	0548	737.7	57 -105	12.2
35	21°40'	157°48'	8/5/56	0930	1000	929.8	45 -105	10.2
36	21°32'	157°39'	8/5/56	1131	1201	769.3	59 -124	12.1
37	21°39'	157°32'	8/5/56	1355	1426	856.5	57 -124	19.3
38	21°30'	157°28'	8/5/56	1605	1635	739.5	67 -124	18.7
39	21°30'	157°19'	8/5/56	1745	1815	978.6	63 -105	13.1
40	21°19'	157°16'	8/5/56	2005	2033	984.5	59 -105	15.6
41	21°19'	157°26'	8/5/56	2230	2303	946.5	57 -112	30.2
42	21°23'	157°35'	8/6/56	0107	0138	558.7	57(?)-119	7.5
43	21°11'	157°34'	8/6/56	0332	0405	779.7	57(?)-105	17.8
44	21°13'	157°43'	8/6/56	0630	0702	749.4	57(?)-112	9.5
45	21°07'	157°43'	8/6/56	0826	0900	948.7	53 -105	16.4

[1] Local civil time corresponding to +10 zone time.

[2] Question mark indicates estimated depth due to insufficient data.

Appendix table 9.--Volumes of zooplankton collected by the middle net on HMS-36, November 1956. All hauls were oblique tows with closing nets between the indicated depths

Station	Position		Date	Time[1]		Water strained	Corrected depth[2]	Sample volume
	N. Lat.	W. Long.		Start Hour	End Hour	$m.^3$	m.	cc./1,000 $m.^3$
3	21°05'	158°04'	11/10/56	1411	1441	987.3	72 -127	4.1
5	21°06'	158°15'	11/10/56	1231	1302	737.4	82(?)-168	4.6
6	20°57'	158°21'	11/10/56	1049	1119	1107.7	59(?)-123	7.0
7	21°03'	158°29'	11/10/56	0912	0943	580.9	63(?)-123	5.2
8	21°13'	158°19'	11/10/56	0721	0747	677.2	54 -105	5.0
9	21°18'	158°14'	11/10/56	0552	0621	412.4	66 -119	6.1
12	21°16'	158°34'	11/10/56	0157	0227	445.5	72(?)-140	9.9
13	21°23'	158°38'	11/10/56	0018	0048	845.8	72(?)-119	12.2
14	21°24'	158°53'	11/9/56	2213	2242	508.7	49 -127	14.7
15	21°25'	159°03'	11/9/56	1928	1958	884.9	66 -127	15.8
16	21°34'	159°06'	11/9/56	1743	1813	1023.4	72 -119	13.1
17	21°35'	158°56'	11/9/56	1555	1626	544.8	89 -127	11.0
18	21°36'	158°46'	11/9/56	1357	1426	684.8	57(?)-145	7.0
19	21°40'	158°35'	11/9/56	1152	1225	764.5	59(?)-130	6.1
20	21°30'	158°29'	11/9/56	1020	1054	1204.0	57 -110	7.5
24	21°50'	158°14'	11/9/56	0349	0418	782.6	50 -119	15.3
25	21°55'	158°07'	11/9/56	0221	0251	1240.1	49 -127	12.7
26	21°46'	158°06'	11/9/56	0100	0131	457.5	44 -140	21.0
31	22°12'	157°45'	11/8/56	1655	1724	1151.3	37 -105	7.0
32	22°04'	157°46'	11/8/56	1525	1554	1301.8	28 -125	1.5
33	21°53'	157°47'	11/8/56	1346	1414	1035.4	49 -100	6.5
34	21°45'	157°42'	11/8/56	1157	1227	876.2	54 -119	8.0
35	21°37'	157°48'	11/8/56	1045	1113	1048.7	57(?)-119	7.6
36	21°32'	157°40'	11/8/56	0843	0913	1139.6	68 -149	3.3
38	21°31'	157°27'	11/8/56	0518	0547	442.8	61 -125	15.4
40	21°19'	157°14'	11/8/56	0205	0235	1767.5	37 -125	7.1
41	21°20'	157°24'	11/8/56	0020	0051	1292.5	87 -119	11.5
42	21°23'	157°35'	11/7/56	2245	2315	1134.8	59(?)-119	8.1
43	21°10'	157°31'	11/7/56	2039	2113	1052.6	63(?)-123	8.8

[1] Local civil time corresponding to +10 zone time.

[2] Question mark indicates estimated depth due to insuficient data.

Appendix table 10.--Volumes of zooplankton collected by the lower net on HMS-32, February 1956. All hauls were oblique tows with closing nets between the indicated depths

Station N	Position		Date	Time[1]		Water strained	Corrected depth[2]	Sample volume
	N. Lat.	W. Long.		Start Hour	End Hour	$m.^3$	m.	cc./1,000 $m.^3$
1	21°11'	157°51'	2/2/56	1456	1526	658.8	141(?)-239	8.5
2	21°04'	157°45'	2/2/56	1714	1749	1833.0	172 -296	3.9
4	21°12'	158°00'	2/3/56	0121	0154	1018.2	137 -273	8.4
5	21°15'	158°11'	2/3/56	0425	0458	568.9	127 -239	11.4
6	21°03'	158°09'	2/3/56	0709	0739	1069.1	145(?)-269	4.7
7	20°56'	158°18'	2/3/56	0955	1025	431.1	112(?)-275	3.7
8	21°04'	158°29'	2/3/56	1248	1319	1308.3	159 -271	4.4
9	21°10'	158°20'	2/3/56	1503	1534	1135.2	127 -248	0.5
12	21°12'	158°35'	2/3-4/56	2359	0029	1277.1	137(?)-263	4.2
13	21°24'	158°41'	2/4/56	0240	0312	1207.4	127(?)-225	7.0
14	21°22'	158°52'	2/4/56	0525	0555	1568.3	112(?)-241	5.2
15	21°22'	159°02'	2/4/56	0814	0844	1226.7	122(?)-248	0.4
17	21°36'	158°53'	2/4/56	1227	1258	965.6	150 -239	3.9
26	21°55'	158°08'	2/5/56	0936	1002	1439.9	102(?)-232	6.1
30	22°15'	157°46'	2/5/56	1755	1825	1439.1	98(?)-214	1.7
31	22°06'	157°44'	2/5/56	2003	2033	1079.3	78(?)-292	8.2
32	21°51'	157°42'	2/5/56	2326	2357	653.1	78 -263	3.4
35	21°46'	157°40'	2/6/56	0520	0548	844.2	131 -225	3.3
36	21°38'	157°32'	2/6/56	0731	0801	1126.7	102(?)-247	0.7
37	21°32'	157°42'	2/6/56	1008	1041	578.6	98 -221	10.7
38	21°30'	157°26'	2/6/56	1249	1317	768.0	141 -233	3.4
39	21°30'	157°16'	2/6/56	1430	1459	635.5	117 -248	4.6
42	21°20'	157°34'	2/6/56	2205	2235	525.2	154(?)-248	5.7

[1] Local civil time corresponding to +10 zone time.

[2] Question mark indicates estimated depth due to insufficient data.

Appendix table 11.--Volumes of zooplankton collected by the lower net on HMS-34, May 1956. All hauls were oblique tows with closing nets between the indicated depths

Station	Position		Date	Time[1]		Water strained	Corrected depth[2]	Sample volume
	N. Lat.	W. Long.		Start Hour	End Hour	$m.^3$	m.	cc./1,000 $m.^3$
P1-53	21°09'	157°52'	5/10/56	0511	0542	664.3	127 -284	3.9
P2-54	21°03'	157°51'	5/10/56	0655	0725	1210.0	127(?)-248	2.6
P4-56	21°15'	157°57'	5/10/56	1120	1151	1367.6	127(?)-209	9.8
P5-57	21°05'	158°13'	5/10/56	1409	1439	923.3	112 -145	7.0
P6-58	20°59'	158°23'	5/10/56	1614	1644	891.8	112 -241	2.8
P7-59	21°04'	158°26'	5/10/56	1809	1840	430.9	112(?)-186(?)	7.9
P8-60	21°14'	158°20'	5/10/56	2007	2038	969.2	102(?)-186	5.5
P9-61	21°14'	158°13'	5/10/56	2126	2157	1103.8	88(?)-170	6.4
P10-62	21°19'	158°19'	5/11/56	0006	0037	283.3	108 -209	5.3
P11-63	21°16'	158°26'	5/11/56	0137	0207	560.7	150 -248	5.9
P13-65	21°21'	158°41'	5/11/56	0621	0652	1312.3	78(?)-170	3.5
P14-66	21°21'	158°52'	5/11/56	0854	0925	892.8	102(?)-170	6.9
P15-22	21°25'	159°05'	5/7/56	0632	0702	774.5	150 -228	4.5
P22-29	21°42'	158°15'	5/7/56	2223	2253	692.4	127(?)-209	4.9
P23-30	21°46'	158°23'	5/8/56	0105	0136	301.9	127(?)-209	13.9
P25-32	21°53'	158°05'	5/8/56	0507	0538	699.6	127(?)-284	6.7
P26-33	21°44'	158°07'	5/8/56	0725	0755	744.6	172 -263	3.9
P28-35	22°02'	157°56'	5/8/56	1219	1251	1183.6	127 -209	1.9
P29-36	22°07'	157°55'	5/8/56	1352	1421	1028.8	112 -209	3.1
P30-37	22°15'	157°53'	5/8/56	1548	1618	1442.9	102 -248	2.4
P31-38	22°15'	157°45'	5/8/56	1733	1804	745.5	159 -248	3.1
P33-40	21°51'	157°45'	5/8/56	2304	2336	1272.0	127(?)-209	7.4
P36-43	21°33'	157°39'	5/9/56	0537	0608	1034.9	127 -209	4.2
P37-44	21°38'	157°32'	5/9/56	0726	0757	946.2	159(?)-263	3.0
P38-45	21°29'	157°26'	5/9/56	1000	1031	1052.5	127(?)-209	2.4
P39-46	21°28'	157°11'	5/9/56	1210	1240	1131.5	117 -209	2.9
P40-47	21°19'	157°09'	5/9/56	1409	1442	1288.0	141 -248	3.1
P42-49	21°22'	157°32'	5/9/56	1843	1916	889.6	137 -225	4.7
P43-50	21°13'	157°30'	5/9/56	2235	2306	1111.3	127(?)-209	1.0
P44-51	21°13'	157°40'	5/10/56	0059	0134	1157.7	141 -233	6.3
P45-52	21°05'	157°42'	5/10/56	0302	0332	650.7	150 -248	6.1

[1] Local civil time corresponding to +10 zone time.

[2] Question mark indicates estimated depth due to insufficient data.

Appendix table 12.--Volumes of zooplankton collected by the lower net on HMS-35, August 1956. All hauls were oblique tows with closing nets between the indicated depths

Station	Position		Date	Time[1]		Water strained	Corrected depth[2]	Sample volume
	N. Lat.	W. Long		Start Hour	End Hour	$m.^3$	m.	cc./1,000 $m.^3$
2	21°02'	157°54'	8/1/56	2240	2312	1445.4	127(?)-248(?)	3.1
3	21°04'	158°04'	8/2/56	0132	0203	1907.4	127 -214	3.4
5	21°03'	158°16'	8/2/56	0721	0752	1133.8	78 -209	2.5
8	21°12'	158°22'	8/2/56	1511	1541	563.8	127 -225	5.0
9	21°14'	158°12'	8/2/56	1727	1801	1281.2	131(?)-261	4.0
11	21°18'	158°25'	8/2-3/56	2340	0010	904.2	78 -233	6.1
12	21°16'	158°38'	8/3/56	0226	0256	750.2	150(?)-248	4.4
14	21°23'	158°54'	8/3/56	0731	0801	1107.2	127(?)-209	5.4
16	21°36'	159°06'	8/3/56	1215	1245	575.8	102(?)-239	5.6
17	21°34'	158°57'	8/3/56	1426	1455	1092.0	141(?)-239	4.7
18	21°34'	158°46'	8/3/56	1638	1709	1057.1	159 -263	4.0
19	21°35'	158°36'	8/3/56	1829	1900	1289.2	150 -217	6.8
20	21°28'	158°35'	8/3/56	2033	2103	1036.5	131 -241	6.2
23	21°46'	158°26'	8/4/56	0432	0502	411.9	150(?)-248	14.8
26	21°46'	158°02'	8/4/56	1104	1136	1023.8	112 -209	10.6
27	21°48'	157°53'	8/4/56	1249	1319	1015.2	150 -209	11.8
28	21°58'	157°55'	8/4/56	1557	1626	979.4	78(?)-256	6.3
29	22°06'	157°58'	8/4/56	1742	1814	539.0	112(?)-271	4.5
31	22°16'	157°48'	8/4-5/56	2354	0026	478.9	141(?)-261	6.5
32	22°05'	157°48'	8/5/56	0255	0327	314.9	141(?)-248	4.4
33	21°54'	157°49'	8/5/56	0516	0548	731.2	127 -209	7.2
34	21°46'	157°43'	8/5/56	0714	0746	1137.9	127 -209	3.2
35	21°40'	157°48'	8/5/56	0930	1000	487.8	102 -209	7.8
36	21°32'	157°39'	8/5/56	1131	1201	704.1	131 -248	10.2
37	21°39'	157°32'	8/5/56	1355	1426	663.1	127 -261	4.2
38	21°30'	157°28'	8/5/56	1605	1635	634.1	150 -248	2.8
39	21°30'	157°19'	8/5/56	1745	1815	714.1	141 -209	6.0
40	21°19'	157°16'	8/5/56	2005	2033	815.7	131 -209	5.5
41	21°19'	157°26'	8/5/56	2230	2303	848.2	127 -225	6.4
42	21°23'	157°35'	8/6/56	0107	0138	507.3	127(?)-241	2.8
43	21°11'	157°34'	8/6/56	0332	0405	620.0	127(?)-209	7.4
44	21°13'	157°43'	8/6/56	0630	0702	346.3	127 -228	19.1
45	21°07'	157°43'	8/6/56	0826	0900	890.5	117 -209	2.9

[1] Local civil time corresponding to +10 zone time.

[2] Question mark indicates estimated depth due to insufficient data.

Appendix table 13.--Volumes of zooplankton collected on various cruises for the monitor series for 1956. All hauls were oblique tows with open nets down to the indicated depths

Ship	Cruise	Station	Position		Date	Time[1/]		Water strained	Depth	Zooplankton volume	
			N. Lat.	W. Long.		Start Hour	End Hour	$m.^3$	m.	Sample volume $cc./1,000\ m.^3$	Adjusted volume $cc./1,000\ m.^3$
JRM	29	1	21°25'	158°16'	1/5/56	2009	2037	1653.9	60	26.8	21.5
		2	21°28'	158°36'	1/5/56	2244	2306	1623.3	60	49.6	28.4
		3	21°25'	158°55'	1/6/56	0125	0147	1437.3	60	41.5	22.1
		4	22°16'	157°45'	1/6/56	1533	1557	1278.6	60	15.4	25.2
		5	21°57'	157°47'	1/6/56	1811	1833	1254.8	60	22.3	24.9
		6	21°36'	157°46'	1/6/56	2053	2115	1251.9	60	52.5	38.1
HMS*	32	10	21°19'	158°14'	2/3/56	1721	1750	1490.6	40	22.7	28.2
		20	21°26'	158°31'	2/4/56	1850	1919	1253.7	50	29.4	29.4
		14	21°22'	158°52'	2/4/56	0525	0555	1080.0	45	25.8	20.7
		30	22°15'	157°46'	2/5/56	1755	1825	1549.1	50	26.0	30.7
		32	21°51'	157°42'	2/5/56	2326	2357	1435.7	50	38.9	21.3
		37	21°32'	157°42'	2/6/56	1008	1041	1530.9	50	15.0	24.5
JRM	30	1	21°27'	158°20'	3/15/56	1930	2012	2537.7	60	17.9	15.2
		3	21°27'	158°38'	3/15/56	2207	2230	1313.9	60	24.7	15.1
		5	21°27'	158°55'	3/16/56	0042	0100	1519.0	60	21.1	11.1
		16	22°20'	157°45'	3/16/56	1617	1640	1345.4	50	17.2	26.0
		18	21°54'	157°46'	3/16/56	1937	1954	1300.6	70	24.1	21.6
		20	21°32'	157°45'	3/16/56	2242	2259	1097.2	60	32.9	18.9
JRM	30	66	21°26'	158°15'	4/20/56	0601	0621	1055.3	80	34.6	30.9
		62	21°28'	158°55'	4/19/56	2301	2323	1299.9	50	42.5	23.8
		51	22°20'	157°42'	4/19/56	0738	0758	1255.1	60	23.1	25.8
		49	21°58'	157°46'	4/19/56	0430	0454	1426.6	50	39.0	27.0
		47	21°39'	157°43'	4/19/56	0130	0150	985.0	50	37.4	19.9
HMS*	34	P10-62	21°19'	158°19'	5/11/56	0006	0037	2028.2	40	32.5	17.3
		P20-27	21°26'	158°31'	5/7/56	1712	1742	1653.5	55	12.6	16.5
		P14-66	21°21'	158°52'	5/11/56	0854	0925	2004.5	35	3.7	5.1
		P31-38	22°15'	157°45'	5/8/56	1733	1804	1520.8	50	18.1	22.5
		P33-40	21°51'	157°45'	5/8/56	2304	2336	1903.3	40	34.3	19.2
		P35-42	21°39'	157°42'	5/9/56	0353	0425	1814.5	50	26.2	16.6
HMS	34	80-M1	21°23'	158°16'	5/29/56	0533	0607	1737.5	60	23.1	18.6
		82-M3	21°24'	158°37'	5/29/56	0818	0851	1889.1	80	14.3	18.7
		84-M5	21°27'	159°01'	5/29/56	1110	1140	1903.6	90	8.4	15.0
		95-M16	22°20'	157°47'	5/30/56	0030	0100	2035.9	65	25.1	13.3
		97-M18	21°59'	157°44'	5/30/56	0320	0350	1870.4	60	14.2	8.7
		99-M20	21°38'	157°43'	5/30/56	0610	0640	2100.1	60	15.8	14.2
HMS	34	145-M1	21°24'	158°15'	6/29/56	1340	1408	2153.4	45	6.4	11.9
		143-M3	21°24'	158°36'	6/29/56	1131	1156	1595.9	60	8.1	14.8
		139-M5	21°25'	158°57'	6/29/56	0633	0700	1700.6	55	18.1	17.1
		153-M16	22°20'	157°47'	6/29-30/56	2345	0012	1612.5	60	34.1	18.4
		155-M18	21°58'	157°49'	6/30/56	0240	0310	1683.5	55	41.2	23.6
		156-M20	21°37'	157°47'	6/30/56	0519	0549	1840.9	55	22.4	18.0
HMS*	35	10	21°24'	158°16'	8/2/56	2007	2036	1500.5	45	18.5	14.8
		20	21°28'	158°35'	8/3/56	2033	2103	1557.9	45	28.4	21.6
		14	21°23'	158°54'	8/3/56	0731	0801	1088.1	40	21.0	23.4
		31	22°16'	157°48'	8/4-5/56	2354	0026	1492.9	50	29.5	15.9
		33	21°54'	157°49'	8/5/56	0516	0548	1332.3	40	52.2	41.9
		35	21°40'	157°48'	8/5/56	0930	1000	1647.2	40	3.3	5.0

[1/] Local civil time corresponding to +10 zone time.

* These data were extracted from the comprehensive survey series (upper net).

Appendix table 13.--Volumes of zooplankton collected on various cruises for the monitor series for 1956. All hauls were oblique tows with open nets down to the indicated depths--continued

Ship	Cruise	Station	Position		Date	Time[1/]		Water strained	Depth	Zooplankton volume	
			N. Lat.	W. Long.		Start Hour	End Hour	$m.^3$	m.	Sample volume cc./1,000 $m.^3$	Adjusted volume cc./1,000 $m.^3$
JRM	32	79	21°24'	158°18'	9/12/56	0504	0536	1523.6	60	48.1	36.6
		78	21°25'	158°32'	9/12/56	0239	0312	1551.3	60	67.0	38.4
		77	21°25'	158°56'	9/11/56	2325	2357	1492.8	60	51.6	28.3
		76	21°15'	157°47'	9/11/56	0937	1015	2142.2	65	30.3	47.6
		75	21°57'	157°44'	9/11/56	0720	0752	1390.7	60	31.5	35.1
		74	21°36'	157°44'	9/11/56	0325	0356	1597.0	55	36.6	22.4
HMS	36	1	21°25'	158°16'	10/19/56	1104	1130	1716.2	40	11.0	19.6
		3	21°26'	158°35'	10/19/56	0858	0928	1914.1	50	14.0	20.2
		5	21°26'	158°58'	10/19/56	0609	0638	1836.5	50	21.2	19.0
		16	22°16'	157°47'	10/18/56	1805	1833	1565.6	65	22.7	25.3
		18	21°58'	157°47'	10/18/56	1527	1557	1520.2	55	17.8	29.0
		20	21°37'	157°46'	10/18/56	1240	1307	1623.5	75	12.3	23.3
HMS*	36	10	21°22'	158°18'	11/10/56	0430	0502	1711.9	50	17.4	12.0
		13	21°23'	158°38'	11/10/56	0018	0048	1786.2	50	13.6	7.2
		14	21°24'	158°53'	11/9/56	2213	2242	1425.6	55	31.5	19.3
		31	22°12'	157°45'	11/8/56	1655	1724	1656.6	45	17.2	23.7
		33	21°53'	157°47'	11/8/56	1346	1414	1784.6	45	6.8	12.6
		35	21°37'	157°48'	11/8/56	1045	1113	1463.9	50	9.8	17.0

[1/] Local civil time corresponding to +10 zone time.

* These data were extracted from the comprehensive survey series (upper net).

Appendix table 14.--Volumes of zooplankton collected on various cruises for the inshore-offshore series for 1956. All hauls were oblique tows with open nets down to the indicated depths

Ship	Cruise	Station	Position		Date	Time[1/]		Water strained	Depth	Sample volume	Adjusted volume
			N. Lat.	W. Long.		Start Hour	End Hour	$m.^3$	m.	$cc./1,000\ m.^3$	$cc./1,000\ m.^3$
JRM	29	1*	21°25'	158°16'	1/5/56	2009	2037	1653.9	60	26.8	21.5
		2	21°28'	158°36'	1/5/56	2244	2306	1623.3	60	49.6	28.3
Makua	F&W-1	1*	21°25'	158°16'	2/3/56	1421	1450	2095.2	60	3.8	6.8
		5	21°25'	158°36'	2/2/56	1133	1203	1788.3	60	5.9	10.8
Makua	F&W-2	1*	21°25'	158°16'	3/2/56	1908	1938	1598.2	200	14.1	13.3
		5	21°25'	158°36'	3/2/56	1605	1635	1532.6	200	4.9	7.4
JRM	30	1*	21°27'	158°20'	3/15/56	1930	2012	2537.7	60	17.9	15.1
		3	21°27'	158°38'	3/15/56	2207	2230	1313.9	60	24.7	15.0
Makua	F&W-3	5	21°25'	158°36'	4/4/56	1206	1230	1595.0	60	7.9	15.0
JRM	30	66*	21°26'	158°15'	4/20/56	0601	0621	1055.3	80	34.6	30.9
HMS	34	P10-62*	21°19'	158°19'	5/11/56	0006	0037	2028.2	45	32.5	17.2
		P20-27	21°26'	158°31'	5/7/56	1712	1742	1653.5	55	12.6	16.5
HMS	34	80-M1*	21°23'	158°16'	5/29/56	0533	0607	1737.5	60	23.1	18.5
		82-M3	21°24'	158°37'	5/29/56	0818	0851	1889.1	80	14.3	10.9
Makua	F&W-5	1*	21°25'	158°16'	6/14/56	1419	1449	1454.2	60	10.0	1.8
		5	21°25'	158°36'	6/14/56	1147	1217	1688.3	60	4.0	7.5
HMS	34	145-M1*	21°24'	158°15'	6/29/56	1340	1408	2153.4	45	6.4	11.9
		143-M3	21°24'	158°36'	6/29/56	1131	1156	1595.9	60	8.1	14.9
Makua	F&W-6	1*	21°25'	158°16'	7/11/56	1444	1514	1665.5	60	12.2	21.3
		5	21°25'	158°36'	7/11/56	1115	1145	1748.4	60	6.3	11.3
HMS	35	10*	21°24'	158°16'	8/2/56	2007	2036	1500.5	45	18.5	14.8
		20	21°28'	158°35'	8/3/56	2033	2103	1557.9	45	28.4	21.6
Makua	F&W-7	1*	21°25'	158°16'	8/22/56	1422	1452	1248.5	60	13.4	24.1
		5	21°25'	158°36'	8/22/56	1119	1149	1731.1	60	16.4	30.1
JRM	32	79*	21°24'	158°18'	9/12/56	0504	0536	1523.6	60	48.1	36.5
		78	21°25'	158°32'	9/12/56	0239	0312	1551.3	60	67.0	38.2
Makua	F&W-8	1*	21°25'	158°16'	10/3/56	1417	1449	1957.1	60	7.5	13.5
		5	21°25'	158°36'	10/3/56	1108	1138	1771.6	60	16.8	30.2
HMS	36	1*	21°25'	158°16'	10/19/56	1104	1130	1716.2	40	11.0	19.8
		3	21°26'	158°35'	10/19/56	0858	0928	1914.1	50	14.0	20.3
HMS	36	10*	21°22'	158°18'	11/10/56	0430	0502	1711.9	55	17.4	12.0
		13	21°23'	158°38'	11/10/56	0018	0048	1786.2	55	13.6	7.1
Makua	F&W-9	1*	21°25'	158°16'	11/28/56	1344	1414	1662.3	60	8.9	16.6
		5	21°25'	158°36'	11/28/56	2055	2125	1756.0	60	17.0	12.3
Makua	F&W-10	1*	21°25'	158°16'	12/12/56	2320	2350	1615.2	60	21.4	11.6
		5	21°25'	158°36'	12/12/56	2028	2058	1618.4	60	13.5	10.3

[1/] Local civil time corresponding to +10 zone time.

* Inshore stations.

Appendix table 15.--Volumes of zooplankton collected at the even-numbered stations on CHG-24, November 1955. All hauls were oblique tows with open nets down to the indicated depths

Station	Position		Date	Time[1/]		Water strained	Depth	Zooplankton volume	
	N. Lat.	W. Long.		Start Hour	End Hour	$m.^3$	m.	Sample volume $cc./1,000\ m.^3$	Adjusted volume $cc./1,000\ m.^3$
2	21°11'	158°19'	11/14/55	2152	2221	1496.6	200	22.3	18.3
4	21°26'	158°16'	11/15/55	0143	0225	2649.2	200	19.1	14.6
6	21°35'	158°32'	11/15/55	0644	0722	1969.0	200	10.9	10.9
8	21°23'	158°54'	11/15/55	1244	1328	2793.6	200	6.9	9.1
10	21°38'	158°44'	11/15/55	1811	1838	1293.8	200	13.4	14.1
12	21°40'	158°19'	11/15/55	2324	2355	1734.0	200	14.5	11.2
14	21°15'	158°18'	11/16/55	0329	0404	1671.2	200	10.1	8.2
16	21°46'	158°04'	11/16/55	0807	0835	1240.2	200	7.4	8.1
18	21°57'	157°51'	11/16/55	1202	1229	1276.9	200	10.2	13.4
20	22°16'	157°56'	11/16/55	1548	1618	1567.6	200	10.1	12.3
22	21°59'	157°47'	11/16/55	2010	2048	2235.4	200	16.7	15.2
24	21°41'	157°50'	11/17/55	0000	0032	1590.4	200	12.5	9.5
26	21°45'	157°41'	11/17/55	0308	0338	1572.9	200	12.9	10.3
28	21°34'	157°43'	11/17/55	0640	0717	1719.8	200	4.6	4.6
30	21°34'	157°30'	11/17/55	1000	1024	1074.8	200	11.0	13.6
32	21°26'	157°37'	11/17/55	1300	1330	1369.0	200	8.1	10.6
34	21°20'	157°30'	11/17/55	1531	1603	1612.6	200	10.4	12.9
36	21°15'	157°38'	11/17/55	1838	1909	1717.7	200	13.3	13.3
38	21°06'	157°42'	11/17/55	2128	2142	875.6	110	24.2	20.3
40	21°12'	157°50'	11/18/55	0030	0102	1557.6	200	16.4	12.5
42	21°01'	157°53'	11/18/55	0336	0408	1508.1	200	14.4	11.8
44	21°15'	158°00'	11/18/55	0739	0816	2030.6	200	10.7	11.5
46	21°03'	158°09'	11/18/55	1057	1135	1970.2	200	14.3	18.3
48	21°15'	158°10'	11/18/55	1419	1450	1546.3	200	10.3	13.2

[1/] Local civil time corresponding to +10 zone time.

Appendix table 16.--Volumes of zooplankton collected at the hydrographic stations on HMS-34, April-May 1956. All hauls were oblique tows with open nets down to the indicated depths

Station	Position		Date	Time[1]		Water strained	Depth	Zooplankton volume	
	N. Lat.	W. Long.		Start Hour	End Hour	$m.^3$	m.	Sample volume $cc./1,000\ m.^3$	Adjusted volume $cc./1,000\ m.^3$
1	20°24'	157°30'	4/27/56	1831	1903	2066.1	125	14.9	14.2
2	19°18'	156°45'	4/28/56	0430	0502	1978.8	135	22.0	20.1
4	16°26'	155°59'	4/29/56	0305	0338	2232.4	170	12.1	10.2
6	15°05'	153°56'	4/30/56	0455	0526	1959.8	170	13.5	12.9
7	16°31'	153°58'	4/30/56	1535	1606	2285.7	150	6.8	7.7
8	18°07'	153°55'	5/1/56	0216	0249	2536.4	135	21.1	17.3
9	19°30'	153°59'	5/1/56	1221	1253	1908.0	135	8.4	10.8
10	21°04'	153°57'	5/2/56	0023	0054	2089.8	180	15.4	11.9
11	22°29'	154°04'	5/2/56	1049	1121	2408.0	170	15.3	19.7
12	24°01'	154°04'	5/2/56	2133	2205	2094.8	170	21.8	17.6
13	23°54'	155°41'	5/3/56	0925	0957	1993.3	170	14.0	17.3
14	24°08'	157°14'	5/3/56	1920	1951	1799.1	170	16.0	14.3
15	24°02'	158°49'	5/4/56	0530	0601	2064.6	160	10.8	9.8
16	24°03'	160°31'	5/4/56	1616	1647	1759.1	200	13.8	16.0
17	24°10'	162°07'	5/5/56	0227	0258	1871.6	185	18.5	14.6
19	21°03'	161°54'	5/6/56	0155	0227	1844.1	200	13.0	10.2
20	20°52'	160°24'	5/6/56	1310	1342	2133.9	135	14.3	18.5
21	20°52'	158°59'	5/7/56	0038	0110	1660.0	200	11.6	8.9

[1] Local civil time corresponding to +10 zone time.

Appendix table 17.--Volumes of zooplankton collected at the hydrographic stations on HMS-34, June 1956. All hauls were oblique tows with open nets down to the indicated depths

Station	Position		Date	Time[1]		Water strained	Depth	Zooplankton volume	
	N. Lat.	W. Long.		Start Hour	End Hour	$m.^3$	m.	Sample volume $cc./1,000\ m.^3$	Adjusted volume $cc./1,000\ m.^3$
118-H2	19°12'	156°38'	6/20/56	0832	0904	2316.2	115	16.4	20.2
119-H3	18°01'	156°01'	6/20/56	2010	2043	2196.9	140	20.0	16.5
120-H4	16°30'	156°00'	6/21/56	0708	0742	1786.1	175	8.7	9.7
121-H5	15°02'	155°58'	6/21/56	1809	1840	2237.2	130	8.4	8.2
122-H6	15°09'	154°04'	6/22/56	0908	0940	1883.2	180	8.2	10.5
123-H7	16°29'	154°02'	6/22/56	1906	1939	1918.7	200	16.6	14.8
124-H8	17°59'	154°08'	6/23/56	0639	0711	1865.4	200	11.8	12.8
125-H9	19°29'	153°51'	6/23/56	1734	1806	1972.0	170	12.5	12.8
126-H10	21°56'	153°49'	6/24/56	0435	0508	1764.2	160	17.3	15.9
127-H11	22°29'	153°53'	6/24/56	1538	1618	1813.9	200	14.9	17.5
128-H12	23°58'	153°53'	6/25/56	0147	0219	1810.3	150	18.7	14.1
129-H13	23°58'	155°34'	6/25/56	1223	1255	1903.9	200	12.8	17.6
130-H14	24°00'	157°11'	6/25/56	2239	2311	1851.8	180	19.8	14.4
131-H15	24°00'	158°54'	6/26/56	1014	1046	2048.6	190	10.1	13.2
132-H16	23°57'	160°35'	6/26/56	2058	2131	2309.7	170	21.1	17.4
133-H17	23°53'	162°09'	6/27/56	0639	0711	1826.3	175	12.6	12.6
134-H18	22°28'	162°05'	6/27/56	1652	1724	1974.0	190	15.9	18.7
135-H19	20°55'	162°01'	6/28/56	0336	0408	2048.6	160	29.4	23.2
136-H20	21°02'	160°26'	6/28/56	1402	1433	1926.7	170	15.9	21.6

[1] Local civil time corresponding to +10 zone time.

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